The Mousterian Sequence of Hummal (Syria)

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1 Summary

The well-site of Hummal, located in the arid steppe region of El Kowm (Central Syria), is scientifically important because of its long archaeological sequence. Beginning probably over a million years ago, humans visited the spring during a range of environmental conditions, and their remains can be found in more than 60 archaeological levels. This thesis focuses on the Mousterian deposits, which comprise the uppermost and longest section of the Hummal sequence. Over 30 archaeological levels display evidence of intermittent site frequentation by Mousterian hominids. The hominids had various purposes in gathering at the water source: depending on the local and regional resource distribution and topography, the spring could serve either for long-term encampments or as a place for resource exploitation.

The fragmentation of the archaeological database makes it difficult to reconstruct the activities that the hunter-gatherers carried out at Hummal. While imperishable lithic artifacts dominate the excavated find samples, animal bones and other organic remains are frequently scarce and severely degraded. Nevertheless, the results gained by a detailed techno-typological analysis of stone artifacts can be taken for a preliminary model of site-use patterns. The technological and typological features of lithic artifacts are likely to prove a valuable source of information in defining the local and regional traditions of technology and the relative positioning of the site in the currently known Levantine Mousterian period.

The Mousterian deposits of Hummal have been under regular excavation since 2002. Since that time, the western and southern parts of the well have been examined more closely, and the two current stratigraphies comprise a sequence more than 5 meters thick. The littoral deposits mirror a steady shift between water transgressions and regressions, which caused the development of a broad ecological spectrum ranging from extended, oxygen-rich lake systems to marshy ponds or water-depleted depressions filled with aeolian sands. Colluviated deposits show evidence of recurring sediment collapses and erosion processes that were provoked by instabilities in the karstic bedrock, water flows and weathering.

The changing biotope varied in its attractiveness to both animals and humans as they searched for drinking water and food. Resource diversity was probably higher in the vicinity of the artesian springs than in the steppe surrounding El Kowm, for herds of grazing ungulates gathered at these waterholes in the course of their annual migration through the El Kowm gap in the mountain ranges that stretch across Syria. The animal bones found in the Mousterian levels of Hummal show that Middle Paleolithic hunter-gatherers encountered steppe-adapted

species such as horses, gazelles, ostriches and camels. Among the camel remains, evidence of a large-sized species that is now extinct shows Mousterian hunters had access to considerable masses of meat at times. In their hunt for these large mammals, the mobile human groups would have benefited from the strategic position offered by the El Kowm area.

The hunter-gatherers also benefited from ready access to the high-quality flint distributed along the Cretaceous and Tertiary formations to the north and south of Hummal. Analysis of the lithic assemblages excavated at Hummal suggests variable patterns of raw material provisioning and use, and these in turn provide information about technological strategies in relation to the site's role in the Mousterian hominids' land-use system. The principal parameters used for reconstructing different strategies of the raw-material economy include the density of lithic waste in a given level and the composition of artifact assemblages. From the presence or absence of specific products such as cores, cortical flakes and tools, as well as their quantity and size, it is possible to decipher variable provisioning strategies that involved targeted forays, the transportation of raw material, opportunistic exploitation of secondary outcrops, or a strong reliance on personal gear. A statistical test for assemblage types corresponding to these different strategies for raw material import and consumption proposes four different assemblage types. Together with the relevant environmental context, these types are informative test cases that can be used for a reconstruction of site functions and land-use systems.

Off-site as well as on-site core reduction saw a systematic application of the Levallois method to obtain standardized blanks. The lowermost Mousterian levels of Hummal reflect the need for a wide spectrum of blank forms that was met by the application of different flaking methods. Common features found across the whole sequence, irrespective of flaking strategy, are the marked elongation of Levallois blanks, the scarcity of Levallois cores and retouched tools, and the systematic recycling of flakes and tools into cores.

Although the sample size is small, the oldest lithic industry (labeled HM-B) is characterized by broad, centripetally prepared preferential flakes and large blades with uni- or bidirectional scar patterns. In the upper two-thirds of the Hummal sequence, a special blank type gains more and more importance: the Levallois point. This coincides with a marked uniformity as regards the choice of core reduction strategies. Triangular blanks were struck exclusively from one-axis Levallois cores with the recurrent unidirectional or lineal method. They are accompanied by elongated flakes and blades for the production of which the knappers used unidirectional parallel prepared core surfaces. Inter-assemblage variability concerns the shape and volume of exploited cores and corresponding morphometric attributes of the blanks.

Two basic variants of Levallois point technology are identified which call for a split of the Upper Mousterian Industry (HM-A) of Hummal into two successive sub-types, HM-A1 and HM-A2 respectively. HM-A2 involves assemblages characterized by narrow, “leaf-shaped” points and a significant proportion of blanks with unidirectional parallel scar patterns. The uppermost HM-A1 industry is dominated by broad-based points, the production of which required strongly converging removals and extended striking platforms.

Despite idiosyncratic techno-typological properties, the Hummal Mousterian industries HM-B and HM-A share certain traits with other Mousterian sites in the El Kowm region and beyond. Despite the frequency of elongated points and blades in HM-A, a comparison with Early Mousterian assemblages, such as Tabun unit IX, shows more differences than similarities. Rather, the clear focus on Levallois points and their high degree of standardization warrant an allocation of the upper Mousterian levels of Hummal to a Late Levantine Mousterian, as is shown by comparisons with sites like Umm El Tlel, Kebara, Amud or Tor Faraj. As regards the HM-B industry, its relative chronological position is still unclear; however, comparisons with Douara III and Tabun unit I suggest that the lowermost Mousterian levels of Hummal belong to the so-called “Tabun C type Mousterian”. They would therefore represent an extension of this facies further eastward than might be expected into the arid, interior part of the Levant.

2 Introduction

2.1 Opening remarks

In 2003, while being a student of Paleolithic Archaeology I stood in Hummal in front of the 4m deep Mousterian sequence which was made accessible by large cuts in the upper part of the well. Having the chance to investigate a succession of several Middle Paleolithic levels is exceptional and it prompted me to start a PhD programme without hesitation. Sure, in the initial stage of research, an overdrawn optimism existed as regards the facility of excavating this huge pile of deposits and the timeframe within which suitable results could be obtained. In retrospect, I would state that deciding to work on unexcavated material for a doctoral thesis meant to take a higher risk than was expected in 2003. First of all, I was thrown in at the deep end regarding the complexity of the archaeological situation and site formation processes in this open-air site. Things weren’t as simple as they looked in the old profiles. Furthermore, Hummal is not located right in our backyard and this meant I had to deduce the maximum amount of information from excavation and artifact analysis in an annual timeframe which was limited to a few weeks. In addition, research had to cut back in terms of technical facilities. As the opening of a surface or trench meant to first dig through several meters of cemented back dirt and well infill by hand, the preparative work generally took two or even more years. And the fact that field work in Hummal covered not only the Mousterian deposits but also underlying archaeological complexes, afforded a careful and sometimes disadvantageous cost-benefit calculation. Given these limitations and stumbling blocks, it is unavoidable that many results are preliminary and that gaps remain in the data base. However, I am confident that the current results of our work in the Mousterian sequence over the past years provide a comprehensive and interesting insight into its archaeological context and the lithic technology of humans occupying the spring. When we compare the initial results obtained at the end of the 70’s and beginning of the 80’s with current knowledge, it is fair to say that a lot has been done, but even more remains.

This manuscript presents the results of archaeological research in the Mousterian sequence of Hummal which began in 2002. It starts with a presentation of the geological and archaeological context in chapters 4 and 5. The second part deals with Mousterian lithic technology. The results of a techno-typological analysis which comprises all excavated assemblages are discussed in chapter 6. These results are then used for reconstructing the technological organization of Mousterian hominids at Hummal and related aspects, such as settlement patterns, in chapter 8. The final chapter deals with the regional perspective of the Hummal Mousterian and its chronological positioning.

The manuscript pursues two principal aims. The first is to introduce the reader who is not familiar with the site and the Mousterian lithics of Hummal to relevant data and to integrate this site into current discussions of the Levantine Mousterian. Second, the manuscript can also serve as a reference for future investigations in the Middle Paleolithic deposits of Hummal. This is the reason why extensive catalogues of geological layers and archaeological levels are given in its annex.

2.2 Presentation of the area

The El Kowm area is located in the arid steppe of Central Syria between the Euphrates River and the oasis of Palmyra (Fig.1). The abundance of Paleolithic and Neolithic sites and the considerable time depth of human presence which is recorded by them made this area a well known place for archaeological research (Besançon et al. 1981; Besançon & Sanlaville 1991; Cauvin 1983; Le Tensorer 2004; Le Tensorer et al. 2001). Regional aspects of geography and geology are described in several publications (e.g. Besançon et al 1982; Jagher 2000; Le Tensorer et al. 2007; Pümpin 2003), and the following section therefore presents only the most important aspects.

Apart from the small village, the term “El Kowm” describes a 20 x 14km wide plateau at 500m a.s.l. The plateau is bordered in the north and east by the Jebel Al Bishri escarpment with elevations of about 600m and to the south by the foothills of the Northern Palmyrides with elevations of up to 800m (Fig.2). These faulted formations are composed of Cretaceous and Tertiary rocks and the plain between them consists of soft Cretaceous and Lower Eocene marls. Apart from the mountainous zones, the area exhibits barely recognizable topographical features, which are small hills, vast alluvial plains, *sabkha* pans and dry valleys. The region of El Kowm comprises a gap between the mountain ranges which stretch across Syria and therefore offers an important transitory passage between the northern lowlands and the Arabian Desert to the south. Migrating herds of ungulates passed through this gap in the past, and humans occupying the El Kowm region certainly benefited from this strategic position in their hunt on large mammals. Another two important factors played a crucial role for the attractiveness the area had for Paleolithic hunter gatherers: perennial water sources and high-quality flint.

Today, the mean annual amount of precipitation lies around 125mm and is strongly fluctuating; rain falls mostly during winter and early spring. The climate is continental with markedly cold winters (average: 5°C) and hot, dry summers (average: 30°C). Surface water is drained off in the north by the wadi Qdeïr into a large *sabkha* pan and to the southeast by the wadis Fatayah and El Murr. Perennial water sources are provided by epithermal artesian springs which emerge along transcurrent faults in the bedrock. They are distributed around the platform of El Kowm and the plateau of Al Qdeïr (Le Tensorer et al. 2001, Fig.5). The water, which is highly saturated with mineral salts, has a temperature of about 30°C. These water sources are an important factor for survival in an arid environment, and this explains the density of archaeological remains in the vicinity of artesian springs. Unfortunately, only little is known about the paleoecological setting at these springs. Intensified agriculture, including extensive irrigation systems, caused profound modifications of the local landscape; the lowering of the groundwater level and overgrazing have reached alarming proportions. Therefore, the current situation hardly delivers any indication for the situation in the past.

Lower Eocene flint of excellent quality can be found in form of nodules on Palaeogene surfaces along the Jebel Al Bishri escarpment and surrounding foothills as well as to the south of El Kowm (see chapter 7 for a presentation of raw material distribution in El Kowm). Permanent access to this important, high-quality resource is reflected by the density of lithic scatters at workshop sites and in stratified well-sites (Le Tensorer et al. 2001).

2.3 The site of Hummal

The site of Hummal is located 1.5km to the north of the village of El Kowm in the southern part of the homonymous plateau (Fig.2). It is a well, the construction and use of which probably started early in protohistoric times. Today, the visible part of the well of Hummal is a more than 14m deep conical structure with a basal diameter of around 3m. At the beginning of archaeological investigations the site was basically a deep shaft which was protected from collapse by concrete and mud brick walls. The well structure was successively dismantled in the course of excavation and is currently a 60m wide step-structured depression at the base of which the former well shaft construction is still visible (Fig.3).

Hummal is one of several sites in the El Kowm area with stratified Paleolithic deposits, but systematic excavations are being carried out only at the well-sites of Hummal, Nadaouyieh Aïn Askar, and Umm El Tlel (Fig.3). Initial investigations in Hummal resulted in discovery of abundant surface material as well as intact archaeological levels within the well deposits (Besançon et al. 1981; Buccellatti and Buccellatti 1967; Cauvin et al. 1979). In the current state of research, the stratigraphy comprises more than 60 archaeological levels, which can be attributed to the Lower, Middle and Upper Paleolithic (Fig.4). The deposits consist of liminic, littoral and terrestrial sediments which reflect a recurrent shift between open lake-systems, small marshy ponds, or a total dry-up of the spring (Le Tensorer et al. 2007). The long archaeological sequence bears an enormous potential for the study of technological evolution and changing patterns of site use over time (Le Tensorer 2004, 2006; Le Tensorer et al. 2003; Hauck et al. in press). Below the Mousterian deposits, which cover more than one third of the archaeological sequence and are the subject of the present paper, Hummalian, Yabroudian, Acheulo-Tayacian and Early Paleolithic levels testify the intermittent presence of humans at this site.

At least four *in situ* Hummalian levels are found in layers 6 and 7. Unfortunately, the transition between the lowermost Mousterian deposits and the uppermost Hummalian level 6a is represented by a massive colluvium which contains a mixed assemblage with artifacts of both Middle Paleolithic cultures in the western part. Layer 6 was also discovered in the southern part of Hummal during last year's excavation. Although the evidence is too scarce for the time being, it is possible that the southern sequence of Hummal documents an uninterrupted transition between the Hummalian and Mousterian. The Hummalian assemblages are characterized by high proportions of blades which were struck from prismatic cores and Levallois cores. Typical elements are narrow and thick blades which were frequently retouched into points and scrapers as well as Upper Paleolithic tool types (Copeland 1985; Le Tensorer et al. 2003); a current PhD program lead by D. Wojtczak (University of Basel) includes a comprehensive techno-typological analysis of the Hummalian. Prismatic blade production was accompanied by a systematic application of the Levallois technique. This is one of the links between the Mousterian and Hummalian in terms of technological strategies, and current research focuses on the techno-typological similarities as well as differences between both lithic industries.

Below the Hummalian deposits, typical Yabroudian artifacts, such as thick non-standardized flakes as well as various Yabroudian scraper types, were found in levels 8 to 12 (Le Tensorer 2006). Given the fact that lithic find densities are low and that certain deposits indicate slow rates of sedimentation during markedly arid periods, it can be assumed that human presence at Hummal was sporadic in the context of rather unfavorable conditions (Hauck et al. in press).

The following layer 13 probably represents an alluvial deposit which contains rounded limestone pebbles and intensively battered lithic artifacts. The debitage is non-diagnostic in terms of cultural affiliation and comprises mainly unmodified flakes and a few simple flake cores. Originally, layer 13 was referred to as a Tayacian in analogy to the non-standardized flake industry found by D. Garrod in layer G of Tabun (Garrod & Bate 1937). However, the term bears inadequate connotations, and current analysis tries to work out the basic technological parameters for a better understanding of the flaking technology. The prefix “Acheulo was attached because of the discovery of two bifaces.

The lowermost layers 15 to 20 deliver an insight into the technology and settlement pattern of the earliest human occupations in the El Kowm area. In several levels, we unearthed well preserved faunal remains as well as lithic artifacts which reflect different modes of tool production and use. Core tools, such as chopping tools, choppers and bolas, occur next to an abundance of flakes which were struck from summarily prepared cores and flakes. Current excavations are focused on the lowest levels of Hummal and the lithic sample is under study within a PhD programme run by F. Wegmüller (University of Basel).

The dating of Hummal is a delicate subject as the site’s geochemical setting is difficult to handle and because problems of radioelement contamination exist. For the time being, a reliable range of TL-dates is only available for Hummalian level 6b, the age of which can be set between 300-200,000 ka BP. Samples for a paleomagnetic study of the lowermost levels 15 to 20 were taken in 2009 and are currently being analyzed.

3 History of research in Hummal

The site of Hummal was detected in the middle 1960's and continues to receive scientific scrutiny. Apart from survey studies, systematic archaeological investigations in El Kowm initially concentrated on early Neolithic remains, such as the Tell of El Kowm. Upon the creation of the first French archaeological mission in El Kowm with Paleolithic archaeologists such as Francois Hours, Lorrain Copeland, and Sultan Muhesen, the well at Hummal was repeatedly investigated. However, twenty years after its discovery, the archaeological situation remained known in a rather patchy way. The extremely deep funnel-shaped structure made the well a dangerous terrain to work in, and construction features, such as concrete walls built during use of the well, blocked access to major parts of the sequence. Nevertheless, it immediately became evident that the site of Hummal holds a long and interesting Paleolithic sequence. Found at the base was a hitherto unknown blade culture, subsequently named "Hummalian" by the discoverers. The Hummalian level apparently lay beneath Yabrudian remains, and Hummal became another site which documents the cultural variability at the transition from the Lower to Middle Paleolithic. Evidence for the latter period appeared in spots behind and above the concrete funnel, showing several Mousterian levels.

In 1997, the Syro-Swiss Archaeological Mission of El Kowm started regular excavations under the direction of Jean-Marie and Hélène Le Tensorer. The initial phase saw the removal of obstructive features and a cut of new profiles. The lowest part of the well was no longer accessible because of successive backfills induced by rainy winters. New stratigraphic and sedimentological data gave rise to a total revision of earlier observations. Confirmation of undisturbed Pleistocene deposits containing a multitude of archaeological levels showed that the initial identification of archaeological complexes had been based on re-deposited layers found in the center of the well. Eventually, the actual Paleolithic sequence came to light and the geomorphological processes better known. Due to an immense cover of modern and historic layers, access to the Pleistocene deposits remains limited up to the present day.[1] As a consequence, small test pits were the only means to retrieve archaeological material and to establish the stratigraphy. Surface excavations started in 1997 and have been followed up to the present day. Significant enlargements of excavation areas were made in the eastern,

[1] All requests to remove the covering layers by bulldozer at favourable parts faced enormous administrative problems or were prohibited entirely. Only in 2005 did we receive the permission to prepare the terrain for a huge test pit in the Western sector with mechanical help.

southern and western part of the well. In the following section, an outline of research history will be given by sketching major steps of investigation in the well-site.

3.1 Step 1 - Discovery of Hummal

The site of Hummal was discovered by Giorgio and Marilyn Buccellati in 1966 during their survey in the El Kowm area. They were seeking Bronze Age remains but instead found an abundance of Paleolithic sites in the region. The site was referred to as "Tell Hummal" and it is reported that flint artifacts resembling already known types from the site of Jerf Ajla near Palmyra were found on the surface:

"*The flints from Tell Hummal also came to the surface as a result of a deep cut opened through the center of the mound to draw water from the well.*" (Buccellati et al. 1967, 306)

One year later in 1967, a Japanese mission with the University of Tokyo carried out a survey in Lebanon and Syria which included a visit to the El Kowm area. This time the well was referred to as "Tell Hassan Unozi", named after the grandfather of the current well-owner. In the mission's report (Suzuki et al. 1970) no details are given, except the fact that Middle Paleolithic remains are present. Illustrations depict one Mousterian point, one discoidal core and one biface. Fortunately, a photo was taken, and it is the only picture that we possess depicting the state of the well at the end of the 1960's (Fig.5).

3.2 Step 2 - Initial investigations

In 1978, archaeological research in the El Kowm area was initiated by the French Mission of El Kowm under the direction of Jacques Cauvin (Cauvin et al. 1979). The research project was focused on the search for Early Neolithic remains (Aurenche & Cauvin 1982; Stordeur et al. 1982). In addition, systematic surveys had been carried out around El Kowm during which principal Paleolithic sites were examined and briefly described. In this context the Mousterian deposits in Hummal received special attention:

"*Des niveaux en place sont visibles en coupe (avec silex et faune) à 3 m 50 du sol primitive, soit à 7 m de la surface actuelle du cratère du déblais. Il comprend de nombreuses et très belles pointes moustériennes triangulaires à talon facetté ou très souvent allongées, des racloirs surtout latéraux ou convergents, quelques burins et grattoirs. L'outillage est de* *couleur noire à surface très brillante, comme vernissée; certaines pièces ont les arêtes émoussées.*" (Cauvin et al. 1979, 89)

Attached illustrations depict Levallois blanks, Mousterian points and various side scraper types. [2] Two aspects suggest that the mentioned artifacts derive from backdirt surfaces. First of all, the glossy patination is a typical aspect of artifacts found in secondary deposits in the spring's center which have later been removed while digging for water, and are now commonly spread on the surface around the well. Second, the mentioned edge damage is frequently found on dislocated artifacts.

In subsequent years, the site was repeatedly investigated by Francis Hours, Lorraine Copeland and Sultan Muhesen. At that time, the well had a maximum depth of around 20 meters. Concrete walls and retaining walls made of clay bricks prevented the funnel-shaped structure from collapse. For this reason, access to Pleistocene sediments was only given below these construction features at the bottom of the well and in some higher exposures (Fig.6).

The archaeological material found in these limited spots was fascinating and apparently gave new insights into the cultural variability during the end of the Lower and beginning of the Middle Paleolithic in the Near East. At the lowest level, a hitherto unknown culture found in a sandy deposit delivered an enormous quantity of blades which seemed to have been produced in a Levallois-like manner. Strikingly, this deposit named "Hummal Ia" was located beneath a Yabrudian assemblage which was embedded in a conglomerate of travertine blocks (Besançon et al. 1981, 41ff.).

Hummal became the eponymous site for the Hummalian industry and initial analyses carried out by Lorraine Copeland (1981b) and Francis Hours (Hours 1982) came to the conclusion that though the blade assemblage has some idiosyncratic techno-typological features, it is set in the realm of emerging blade-dominated industries at the beginning of the Middle Palaeolithic. Both researchers struggled with the question whether this industry can be considered as being produced exclusively by the Levallois method. The presence of Levallois blanks warranted a link to the Levalloiso-Mousterian, and in this regard the Hummalian differed from synchronous non-Levallois blade industries, such as the Pre-Aurignacian of Yabrud, the Amudian of Tabun or the Abu Sif material. The material being totally different from the Yabrudian and possessing a special tool kit based on retouched blades and points,

[2] In 1979, the Hummalian blade industry had not yet been defined, and therefore some of the collected artifacts could have probably been attributed to the Hummalian. Burins and end scrapers are mentioned in the Mousterian assemblage, but recent analysis reveals that if end scrapers or burins are present, they appear atypical. Concerning the Mousterian, Upper Palaeolithic tools are extremely rare and many alleged types have to be regarded as cores on flake or edge-damaged artifacts.

Hours added the Hummalian as a new culture to the complex cultural scenario at the end of the Lower Palaeolithic:

"*L'assemblage de Hummal I a, situé pensons-nous sous un niveau yabroudien, se place à une époque où les industries n'apparaissent pas encore bien fixés, à la charnière entre le Paléolithique inférieur et le Paléolithique moyen, si bien qu'il est difficile de les faire entrer dans ces cadres trop rigides.*
[…]
La réunion de tous ces éléments, nous parait former une ensemble original dont la position chronologique est intéressante, différent de ce qu'on connaît à la même époque. Nous proposons de lui donner le nom de « Hummalien »." (Hours 1982, 45)

The uniqueness of the Hummalian was later corroborated by a study of Lorraine Copeland on a broader material basis (Copeland 1985). A main question concerned the chronological placement of this blade industry in relation to the "Mugharan tradition" at the coastal Levant or early Mousterian assemblages showing serial blank production, such as Abu Sif C, Hazar Merd D or Tabun D. Techno-typological analysis resulted both in similarities and differences and undermined the singular appearance of the Hummal Ia assemblage. Interesting for the remainder of this study is the fact that a direct technological continuation of the Hummalian idea in the overlaying Mousterian was immediately proposed.

The Yabrudian assemblage Hummal Ib consisted of 703 artifacts including 10 bifaces and many Yabrudian scraper types. Published in 1983, it was placed next to already known assemblages like Yabrud itself, Tabun E-F or Adlun (Copeland & Hours 1983). Special attention was laid on the bifaces and scraper types, tools which were equally found in other sites of the El Kowm region. Although it became clear that Hummal Ib is attributable to the so-called "Mugharan tradition" proposed by Jelinek (1982a), the significance of bifaces as chronological or cultural markers remains questionable.

In 1981 Francis Hours collected travertine samples in the Yabrudian complex Ib of Hummal and from the neighboring well-sites Aïn Beni Ali, Umm Qbeiba, Tell Arida and Umm El Tlel for U-series age determination. The Umm Qbeiba samples were taken from Yabrudian and Mousterian deposits, the Umm El Tlel and Tell Arida samples from Yabrudian deposits, and the Aïn Beni Ali sample was without any archaeological context. U-series dating was done at the Institute for Nuclear Chemistry at Cologne University and delivered an unexpectedly old age for the Yabrudian deposits in the light of prevailing assumptions about the chronological position of this cultural facies at that time (Hennig & Hours 1982). The

Hummal sample was dated to 157 ka BP, the Tell Arida sample to 102 ka BP, and the Yabrudian samples from Umm El Tlel and Umm Qbeiba to 140 ka BP and 247 ka BP respectively. Unfortunately, subsequent ground water analysis showed that a high natural U-content resulted in an erroneous calibration rendering the dates too young. The age of the Yabrudian, as it is known today from other dated Levantine sites, is at least 100,000 years older. Given these results and the complex site formation processes in the El Kowm springs, it became clear that other dating methods had to be focused on.

In 1982 Jean-Marie Le Tensorer and Sultan Muhesen joined the French archaeological mission at El Kowm for a further investigation of the Pleistocene deposits at Hummal and other Paleolithic sites in El Kowm. In 1983 the topography of the well was summarily documented and two major profiles (P1 and P2) investigated. Profile 1, situated in the southeastern part of the well, gave insight into the rather chaotic depositional sequence at the bottom of the well (Fig.7). Just opposite to profile 1, a long cut running north-south allowed a partial examination of the upper part of the Pleistocene sequence, although construction walls still blocked a comprehensive documentation. On the basis of the stratigraphic data it became clear that the peculiar position of the Yabrudian between the Hummalian and Mousterian was no longer tenable, because all previous observations were based on sand deposits in secondary position. Investigation of the depositional sequence was accompanied by sedimentological analysis and a collection of artifacts for use wear analysis. However, due to the conclusion that the majority of archaeological levels showed a strong alteration by diagenetic processes, the use wear analysis was no longer pursued. The yearly investigation of the well ended in 1985 and a systematic excavation of Hummal did not start until 1997. The geological and archaeological sequence known in 1985 was as follows:

- *complex Ib* - travertine associated with Yabrudian artifacts:

  The cemented conglomerate composed of abraded travertine blocks was found at the base of the well with unknown depth. At the lower part of the deposit, several Yabrudian levels have been located and 703 artifacts collected. The tool kit consists of typical Yabrudian scrapers and some Upper Paleolithic types (Copeland & Hours 1983, 25ff.; Le Tensorer 2004, 224).3

- *complex Ia and II (lower part)* – sand deposit with Hummalian and Mousterian remains:

[3] As artifact density in recently excavated *in situ* Yabrudian levels (8-12) is low, technological analysis of the Hummal Yabrudian is still mainly based on the mentioned re-deposited assemblages (Al Qadi 2008).

Complex Ib is followed by a cemented quartzitic sand deposit at the base. The lower and middle part delivered several Hummalian levels from which about 7000 artifacts have been collected. Based on this sample, the Hummalian industry has been identified and described (Hours 1982; Copeland 1985). At the top, a Mousterian assemblage (IIb), which stood out because of its laminar appearance (blade index: 47.08), was found in loosely packed quartzitic sands (Le Tensorer 2004, 225).

- *complex IIa and III* – conglomerate and bone breccia with Mousterian assemblages:

  Top of complex IIb had been eroded by a breccia consisting of limestone pebbles and cemented quartzitic sand in which numerous bone fragments and Mousterian artifacts were found. It was immediately evident that this deposit occurs in a secondary position, a fact that is actually true for all complexes except V and VI. The detritic sequence continues with cemented gravel and sand containing archaeological complex III. Due to protection walls blocking access to the upper part of complex III, this part of the sequence has been only examined through a very small opening (Le Tensorer 2004, 225).

- *complex IV* – sand deposit with Mousterian remains:

  Artifact bearing sands have been detected in the north-western part of Hummal just opposite the previously mentioned deposits. Occurring at the same depth as complexes II and III, a lateral facies change seemed probable. The quartzitic sand enriched with clay particles delivered a Levalloiso-Mousterian assemblage with elongated blanks (Le Tensorer 2004, 225). At the top it cut a blackish clayey sediment which is nowadays attributed to the Yabrudian complex and referred to as layer 10.

- *complex V* – organic clay and quartzitic sand:

  During initial investigation of the well, this deposit has been labelled “niveaux tourbeaux” because of its high organic clay content and distinct black colour. No artifacts were found and in its southern part, the black clayey layer had been eroded with the accumulation of sterile quartzitic sands, also called “sables supérieurs B” (Besançon et al. 1981, 50; Le Tensorer 2004, 226)

- *complex VI* – clayey carbonatic silt with ”transitional culture”:

  In a 1 m thick fine-grained carbonatic sediment, two archaeological levels were identified (VIa and VIb). Struck by the preponderance of non-Levallois blades, the first researchers interpreted the assemblages as belonging to a transitional culture between the Levalloiso-Mousterian and Upper Palaeolithic (Le Tensorer 2004, 226).

- *covering deposit* – silt and sand with isolated artifacts
  Due to detection of a few dispersed artifacts, the deposit above complex VI had been interpreted as re-deposited material. The loess-like sediment showed a thickness of roughly 8 m and was generally attributed to the Holocene (Besancon et al. 1981, 50; Le Tensorer 2004, 226).

3.3 Step 3 – Systematic investigations

In 1989 a joint Syro-Swiss archaeological mission under the direction of Jean-Marie Le Tensorer and Sultan Muhesen was launched. Within this framework, regular excavations were carried out in the Aucheulian site of Nadaouiyeh Aïn Askar together with a survey programme covering the El Kowm region (Jagher 2000). In addition, raw material provenience studies were started (Diethelm 1995). Not until 1997, while excavations in Nadaouyieh Aïn Askar continued, the Syro-Swiss project began to re-investigate the well of Hummal. Unfortunately, a major surface erosion happened in 1987 during a winter with heavy rainfall and the well was filled to a depth of around 13m below datum (Fig.6). Therefore, the lower third of the well funnel was no longer accessible.

From 1997 onwards the well was successively enlarged by removing the modern infill and colluviated deposits along the walls in the northern half of Hummal. Long trenches running parallel to the northern irrigation channel allowed a detailed documentation of the undisturbed Pleistocene sequence. For the first time, the Yabrudian and Hummalian complex were found *in situ*. Due to the steep well, surface excavations remained limited to a few square meters. Small test excavations in the lower part of the Pleistocene sequence were possible in the area where the former water pumps were placed in concrete basements. In 1999, the Mousterian sequence and overlying sediments were investigated in detail with the help of long north-south running profiles in the western section of the well. Despite promising results, field work in Hummal remained limited due to the sharing of manpower, budget and mechanical facilities between the Hummal excavation and fieldwork in Nadaouiyeh Aïn Askar. This explains the delay in topographical surveys, and not until 2001 did a detailed measurement take place which allowed the mapping of the topographical situation. In 1983, Francis Hours had the idea to cut a large trench through the southern part of the well, and initiated this enterprise with the help of a dredge. Unfortunately, work in this trench was no longer pursued thereafter until field work started again in 2005 in the adjacent area. Three test pits and a large surface have been excavated since then, delivering complementary insights into the stratigraphy and paleotopography of the site.

A considerable part of field research and archaeological analysis is conducted within Master and PhD programmes. Micromorphological analysis was performed in 2000 and 2001 for a Master Thesis at Basel university by K. Ismail-Meyer. A PhD project run by D. Wojtczak which concentrates on the Hummalian culture started in 2003 and since then surface excavations were carried out on $26m^2$ in the Hummalian levels accompanied by small test pits in the eastern and western part of the well funnel. Two years later, the Mousterian complex equally came into focus with a large cut in the western section of the well, and within a PhD project started in 2004 by the present author, systematic surface excavations and large test pits in the surrounding area have been carried out since then. Excavation of the Hummalian and Yabrudian levels in the central part of the well allowed extended access to the lowest levels containing Lower Paleolithic flake and pebble cultures. This enabled the beginning of a third PhD project run by F. Wegmüller in 2008 focussing on the Lower Paleolithic complex. The extension of archaeological investigations resulted in a complex topographical situation and exponential increase in field data. The gain in information obtained through surface excavations and a growing number of test pits forms the base of a fourth PhD programme, run by D. Schuhmann, in which a digital model of the current and Pleistocene topography will be developed.

3.4 The discovery and preliminary analysis of Mousterian levels before 2003

Immediately after the detection of the site by Buccelatti and Buccelatti in 1966, the archaeological potential of the well, especially in respect of Middle Paleolithic remains, was highly estimated (Buccelatti et al. 1967).[4] This observation was corroborated one year later during the systematic survey carried out by the Japanese mission (Suzuki et al. 1970). Three main characteristics of the Hummal Mousterian already caught the eye at that time: several *in situ* deposits at a depth of at least 4m below surface, the abundance of Levallois points which

[4] In the mentioned survey report it was stated that the finds of “Tell Hummal” strongly resemble artifacts found by B. Schroeder and his team (Schroeder 1969) in the site of Jerf Ajla near Palmyra.

are often very elongated, and the glossy patination on many items.[5] Published illustrations show various scraper types and retouched blades collected on the surface around the well.

Ongoing research revealed the presence of Levallois points, centripetally prepared flakes and a scarcity of retouched tools.Although blades appeared to be less frequent than in the Hummalian deposit Ia, an ongoing technological tradition was postulated (Besançon et al. 1981, 1982; see also Copeland 1983b, 308). In overlying layer III, which was located on the Western wall about 1m above layer II, 124 artifacts were taken as a sample. Because of a dominance of flakes in the assemblage, a change in technology seemed to be visible with an orientation of blank production towards oval shaped Levallois flakes and side scrapers. In the uppermost Mousterian layer IV which was separated from layer II by a travertine formation, a renewed augmentation of blades seemed to represent a continuation of the blade tradition showing its roots in the Hummalian. 198 artifacts were collected and typical ("*vraies*") Levallois points appeared as characteristic constituents. Despite the observed differences between the assemblages, a strong homogeneity regarding the technological style gave the impression of a long and stable cultural tradition

However, things became more and more complicated. The discovery of level VIb in the upper part of the then known Pleistocene sequence raised many questions. In this level, Mousterian-like artifacts appeared, but striking was the abundance of non-Levallois blades. The position of level VIb above the hitherto known Mousterian layers provoked considerations about the relative chronology of this assemblage. In a supplement published in *Ancient TL*, it was noted:

"Level 6b was enigmatic because it consisted of abraded and patinated Mousterian-like blades but the level was far above the other Mousterian layers. Could it be transitional to Upper Palaeolithic?" (Ancient TL supplement 1988, Oxford Laboratory, Entry 22).

Together with the peculiar position of the Yabrudian layer (Ib) between the Hummalian (Ia) and lowest Mousterian complex (II), the Levalloiso-Mousterian of Hummal seemed to be framed by three industries, representing a long technological tradition. At the base, the Hummalian testified a systematic blade production which later reappears to various extents in the Mousterian complex. The overlying Yabrudian complex with its specific scraper

[5] It has to be mentioned that the Hummalian had not been defined as a distinct culture at that time. Insofar, some of the observed and illustrated blades, end scrapers and burins are probably Hummalian artifacts. A comment has to be made concerning Upper Palaeolithic tools. Recent analysis reveals that if end scrapers or burins are present, they appear atypical. Concerning the Mousterian, Upper Palaeolithic tools are extremely rare and many alleged types have to be regarded as cores on flake or edge-damaged artefacts.

types, flake production and some bifaces seemed to coincide with Late Acheulien and Levalloiso-Mousterian industries, thus connecting the two (Copeland & Hours 1983, 36). And finally, the Levalloiso-Mousterian itself is overlain by a yet unknown culture with Upper Paleolithic affinities.

This idea changed dramatically with a more detailed investigation of the cultural sequence. Due to the presence of cement walls which hampered a more complete insight into the archaeological sequence, the Mousterian was attributed to three levels (II (upper half), III and IV) until the beginning of the 1990's (Le Tensorer 1996). Only by digging new trenches along the western and northern walls and a backward shift of old profiles did the actual *in situ* Middle Palaeolithic sequence come to light. Now the problematic interpretation of level VIb found a sudden solution because of the fact that it represents an *in situ* Hummalian assemblage situated below the Mousterian[6]. Furthermore, it was recognized that all former Mousterian layers simply represent eroded assemblages not being in primary stratigraphic position. Undisturbed Mousterian layers were found along the eastern wall when cutting profile 3, but the most complete deposits were encountered just opposite in the Western part while removing the ancient backdirt. Finally in 1999, the most representative Mousterian sequence was documented in profiles P4 and P6. Three years later a small test pit was dug in the north-western corner of the western section in order to better understand the uppermost part of the Mousterian sequence and to document the contact between archaeological deposits and the modern well infill. Research history concerning the Levalloiso-Mousterian sequence until the beginning of first surface excavations in 2003 is summarized in Table 1.

3.5 Excavation of Mousterian deposits since 2002

The following section briefly describes the progress of excavation in the Mousterian deposits of Hummal between 2002 and 2009. The excavation surface sizes and those of the levels excavated are listed in Table 2. The locations of the excavation surfaces, test pits and documented profiles mentioned in the text are shown in Figure 8. With the exception of yet unresolved questions regarding the depositional context in areas outside the currently known dolina, the geological and archaeological results are presented in the chapter 4 and 5 as well as appendix A and B.

Excavations in the western section of Hummal posed several technical problems. These included the question of working security in this exposed area bordering the well funnel,

[6] During the first investigations of the well in the beginning of the 80's, the deposits ranging from level VI to the top had been referred to as Holocene, and as such no further fieldwork was done in this part of Hummal.

and the considerable weathering and cementation of many layers. The weathering and cementation required the frequent use of excavation tools such as percussion drills, which are not ideally suited to the careful recovery of artifacts. Moreover, the substantial desiccation of the sediments made it difficult to recognize subtle changes in facies. In the current state of research, surface excavations covered the upper part of the sequence, whereas access to the lower Mousterian levels was available only in test trenches. This explains the limitations in lithic and faunal sample size for levels 5b7 to 5g in the western sequence and for levels 5DI to 5FVII in the southern sequence.

Investigation of the Mousterian deposits in Hummal was mainly confined to the site's western and southern sections (Fig.8, Fig.9 and Fig.10). The decision to open these sections followed technical considerations and observations made before 2002. At the outset, fieldwork strategy relied on the situation documented in the parallel, north-south running key-profiles P3, P4 and P6, which were cut in 1999. A comparison between these cuts shows that the depth and preservation of Mousterian deposits changes considerably within a distance of 6m, with less favorable conditions in the eastern part. The considerable depth and archaeological potential of the western sequence prompted us to center archaeological research on this part of the well. Overlain by massive backdirt and Holocene deposits, the upper limit of Pleistocene deposits appeared at around 6m below datum. It was obvious that a large-scale excavation of the Mousterian complex would be a worthwhile endeavor but would also be difficult, owing to the steepness of the well funnel (see picture in the upper left of Fig.10).

In 2002, J.-M. and H. Le Tensorer opened a small test section of two square meters in a north-western corner that was accessible at that time (Fig.10). The test pit covered the uppermost Mousterian complexes V1 and V2 and made it possible to locate archaeological levels 5a2, 5a3, 5b1, 5b2, 5b3 and 5b4, which were documented in profiles 28 and 29. For the purpose of excavating the upper Mousterian levels on a larger surface, the north-western corner was enlarged in 2003 and a grid was established over an area (surface A) measuring $13m^2$ (Fig.8 and Fig.10). Profiles 4 and 6 served as a reference for level identification. Technical facilities afforded working platforms in the perimeter and for this reason an area of roughly 7x5m was opened from the beginning. Due to the considerable volume of modern and historical backdirt, and to the lack of mechanical facilities, the preparatory work became time-consuming. It went on for three weeks.

Complexes I (recent backdirt), II (modern/historical) and III (early Holocene?) were excavated rapidly, sediment change was noted, and findings were collected with sub-layer provenance. Except for displaced lithic artifacts and a few ceramic fragments in layers II-2 and II-4, no architectural features or other archaeological remains came to light. The northern and western walls became profiles 42 and 43, which documented the sequence of modern and historical levels in this part of Hummal. Archaeological levels 5a1 and 5a2 revealed plenty, but the material consisted of loosely distributed artifact scatters without horizontal or vertical concentrations. To minimize time investment, excavation proceeded in arbitrary levels of 15cm; each square meter was photographed and findings were collected by fourth-square meter. With the discovery of archaeological layer 5a3, the primary focus of the 2003 excavation had been attained. From then on, all objects were recorded in three dimensions.

Fieldwork in 2004 saw the excavation of a test pit (W1) in section Y: 31-33 / X: 99-101 adjacent to the 2003 surface (Fig.8 and Fig.10). The principal aim was to gain a closer insight into the depositional sequence below complex V1 and to establish facies correlations between this section and profiles P4 and P6, which are situated more than 10m to the east. The depositional sequence documented in trench W1 (profiles 44 and 45) proved that the geoarchaeological situation is more complex than had been suggested, in the sense that levels 5c, 5d, 5e, 5f and 5g defined in P6 were not identifiable further west. Instead, level 5b appeared as a thick alternation of detrital carbonate muds and freshwater carbonates, comprising at least seven archaeological levels.

In 2005, a major extension of the western section enabled the excavation of surface A on a larger scale (Fig.8 and Fig.11). The 2003 surface was extended to $20m^2$ and an adjacent surface (B) of $5m^2$ to the west served as check for the extension of archaeological levels. To gain insight into the nature of deposits and archaeological situation outside the currently visible dolina, a large trench (W2) with a twofold direction was initiated, and investigations started at its northern end at a maximum distance from the excavation area in the western section. Fieldwork in 2005 also involved the beginning of archaeological investigations in the southern half of the well. Excavation started in two north-south running test pits (S1 and S2), each measuring $11.5m^2$. They covered the uppermost Mousterian levels 5AI to 5AIV, and it became clear that the depositional context in the south showed no parallel to the observations which were made in the western part (see chapter 4).

Concerning the western section, the 2003-2006 surface excavations had already yielded usable lithic samples for a techno-typological study of the Hummal Mousterian. However, as they were confined to the upper part of the sequence, the database for lithic analysis remained incomplete. For this reason, we decided in 2006 to dig a trench in the eastern part of the western excavation area to get access to the lower part of the sequence, thereby removing profile P4 (Fig.8 and Fig.11). Trench W3 covered $6m^2$ and was rapidly excavated without three-dimensional artifact measurements. Inside the trench, the stratigraphy of profiles P51 and P52 delivered new insights into the dynamic geomorphological process which affected the site. It showed that the Mousterian sequence defined in 1999 changes dramatically within a few meters to the west (see chapter 4). The fact that Mousterian levels 5c to 5g were only found as remnants due to sediment collapses into the spring mound required a cost-benefit ratio of future surface excavations in the western section. They were continued in 2006 with an additional $5m^2$ surface (C) to check for the northern extension of archaeological complex 5a and 5b, but were not pursued subsequently (Fig.8 and Fig.11). In the southern half of the well, work in trench S2 also terminated.

In 2007, fieldwork in the western part was confined to the excavation in trench W2. In its northern extremity, no facies change or archaeological level appeared, despite a horizontal and vertical extension of excavation; the sole identified deposit consist of a dense, gypsitic carbonate which extends over 2.5m in depth and does not reveal any evidence for a correlation with intra-dolina deposits. For this reason, fieldwork in W2 shifted to its southern extremity, which is closer to the western excavation area (Fig.12). Excavations in the southern section involved a continuation of trench S1 and the beginning of a surface excavation between S1 and former trench S2. In addition, an east-west running test pit (S3) was dug to observe the extension and geometry of stratification of Pleistocene complexes S-V1 and S-V2.

In 2008, work in the western trench W2 continued and finally delivered interesting results concerning the spring's topography during the accumulation of the uppermost Mousterian layers. A massive travertine formation, overlain by a thin clay layer and several gypsitic freshwater carbonates, was discovered at X: 96. The travertine presumably represents the Pleistocene spring margin (see chapter 4.4) and is still the only indication for its extension; micromorphological and sedimentological samples were taken and analysis of the extra-dolina deposits is currently underway. In the southern part of Hummal, the surface excavation was restricted to $5m^2$ and trench S3 was continued only in its western half, whereas work in trench S1 went on within the limits set in 2007 (Fig.12).

Last year's field work in Hummal saw continued excavations in the same areas except for a termination of work in trench W2. An overview of the site's topography and excavation at end of 2008 is shown in Figure 3.

Excavations in Hummal were accompanied by systematic sampling of sediments, travertines and organic remains. More than 15 micromorphological samples, of which 10 have been analyzed, were taken in various sections. The results enabled a reconstruction of sedimentation processes and geomorphological aspects in sediment complexes II and III as well as Mousterian layers 5a3, 5a4, 5b1, 5b2, 5b3, 5b4, 5DV, 5E, 5g and 5h (Meyer 2001; Hager 2008). Due to an insufficient infrastructure, it was not possible constantly to sieve the backdirt. Consequently, the proportion of small lithic and bone debris is underrepresented in many assemblages. In 2001 and 2004, dosimeters for TL-dating were placed in levels 5a3, 5b4, 5b6 and 5g, and gammaspectrometry was taken for level 5g. Due to the fact that the spring of Hummal shows irregularities in U-series which cannot be reconciled with the preceding measurements and palaeodose calibrations, a new dating program is envisaged for 2010.

4 Geological aspects and site formation processes

4.1 Introduction

Hummal is a spring site, and thus sedimentation is principally governed by the degree of spring activity. Sediments in Hummal reflect differential water contents, and as such the sequence shows an alteration of limnic, littoral and terrestrial sediments (Le Tensorer et al. 2007; Meyer 2001). High water levels correlate with carbonate precipitation which is encountered as cemented carbonate mud during excavation. In times of decreased water supply, the pond became a marshy depression. Such periods can be traced throughout the Mousterian sequence in the form of brown or grey colored clay accumulations representing former soil formations. Calcified remains of *Artemisia* and *Poacea* provide some idea of the vegetation cover. Prolonged dry periods are indicated by a significant amount of quartzitic sands in certain layers, especially in the lowest part of the Mousterian sequence. Accumulation of these aeolian sands is often marked by a combination of slow rates of sedimentation and some deflation. However, oscillation between dry and wet phases was commonly rapid, as can be inferred from fine-leveled successions of respective sediments. Consequently, there was a rapid burial of archaeological remains, which are often preserved in perfect condition. Embedded in poorly developed and partially eroded soil formations, the archaeological horizons were then overlain by massive carbonatic silt deposits. Travertine formations represent shifts of the water outlet and are found throughout the sequence. The irregular spatial distribution of the travertines makes it difficult to assess the well mound's actual extent at different periods.

The geomorphology of the artesian water sources in El Kowm is extremely complex (Jagher 2000; Le Tensorer et al. 2007). Occasionally, combined hydrological and tectonic processes caused instabilities in the bedrock, leading to diverse post-depositional alterations of the stratigraphy. The results were sink-hole effects and displacements of entire sediment packages. Such deformations left thick sand deposits at the bottom of the well. Dislocated Mousterian deposits may contain thousands of artifacts and faunal remains and represent rich archaeological levels, the original stratigraphic position of which is unknown. Distortions, vertical dislocations and varying degrees of subsidence can be observed in geologically intact layers near the spring's vent. In addition, chemical processes played an important role in diagenesis (Le Tensorer et al. 2007; Pümpin 2003); an illustrative example is the glossy patina on many artifacts, formed by the accretion of SiO_2 on their surfaces.

About one third of the investigated archaeological sequence at Hummal is made up of Mousterian deposits. We identified 39 geological layers in the western part, and 34 layers in the southern part of Hummal. Found within these sequences were 38 archaeological levels, including deposits which contained only a few, isolated objects. Table 3, Table 4, and Figure 13 present all geological layers identified so far. The definition of sediment types is based on the geoarchaeological research carried out in Hummal and Nadaouiyeh Aïn Askar (Le Tensorer et al. 2007; Meyer 2001; Rentzel 1998). The lists have to be considered as an exhaustive compilation in which the status of some layers is not clear yet. The reason for this uncertainty is a problem of correlation within and between the investigated sections of Hummal (see Figure 13 for tentative correlations between the western and southern section). Certain layers show changes in facies type or a restricted extension due to erosion, and thus, the depositional sequence identified in one area can be totally different in an adjacent area even though the distance constitutes only a few meters. For this reason, uncertain correlations are not considered and it is possible that one layer was labeled and listed as two separate layers because of differences in its appearance. In the western section, this concerns a certain number of deposits which were defined in profiles 4 and 6 in 1999 and which were no longer recognizable in adjacent trenches dug in 2004 and 2006.

Chapter 4.3 describes the nature, succession and depositional context of identified sediment complexes in the western and southern part of Hummal. In appendix B a catalogue is given in which each single layer is described in detail.

4.2 Present state of geological and geoarchaeological research

In the case of Hummal, geological research lags behind archaeological investigation. This is a problematic aspect as the site shows a complex formation history. Especially lacking is a comprehensive geomorphological approach which integrates all existing data in order to develop an understanding of site-formation and the significance of the locality from a regional perspective. Despite valuable insights gained by micromorphological and preliminary sedimentological analysis, we are far from grasping the site’s evolution and paleotopographical situation. Furthermore, the paleoecological history of the spring is a subject that remains to be worked on in the near future. Considering all these vacancies, it has to be stressed that most of the layer descriptions, depositional models and environmental reconstructions given in this work are to be considered as preliminary and hypothetical.

Micromorphological research is done by K. Ismail-Meyer who wrote her Master thesis at the University of Basel about the Pleistocene sequence as it was known in 2001 (Meyer 2001). Since then, numerous test pits and surface excavations have led to a multiplication of identified deposits in the Mousterian sequence, many layers of which were identified and summarily described in the field by a non-geologist. Tables 3 and 4 reflect this unequal state of research. Systematic sedimentological analysis started in 2008 and is currently integrated into a Master program led by A.-S. Martineau at the University of Dijon. The bulk of data which is presented below and illustrated in various figures and tables is largely based on research done by these two persons combined with field observations made by the current author.

A final remark concerns the signature of geological layers. Since 1997, deposits were combined to complexes on the basis of archaeological data. Instead of geological features, the attribution of lithic artifacts to certain Paleolithic periods served as a means for differentiating the sediment complexes in Hummal.[7] In the early phase of investigation (1999-2002), all Mousterian levels were ascribed to a single "Mousterian complex" and coherently labeled with number "5". This number is followed by a letter identifying either a single level or a sedimentological unit, such as 5a or 5b. Levels within a sedimentological unit were tagged with an Arabic numeral behind the letter, such as 5a1 or 5a2 for example. Sterile layers were not labeled nor described. To overcome these inconveniences and to separate the archaeological sequence from the geological one, the conventional system was retained for archaeological levels and a new labeling system was introduced for geological layers, which, for the moment, is only applied to the Mousterian sequence. We retained the number "V" for the Mousterian complex, but labeled each layer and sub-layer with Arabic numerals instead of letters. To avoid confusion, all layers of the southern sequence are prefixed with an "S".

4.3 Geomorphological aspects

The majority of lacustrine sediments accumulated in a lake basin with a varying extension and gradient. Progradation of the littoral zone probably occurred during times of increased carbonate precipitation and redeposition of terrestrial material. The lake's depth varied according to spring activity and input of meteoric water. The Mousterian sequence contains sediments which were deposited in the profundal zone of a relatively deep lake (e.g. varve-like sediments, micrite) as well as evaporitic *sabkha*-formations which are related to ephemeral or perennial ponds.

[7] This aspect explains why archaeological level 4 or geological layer IV are missing in the Mousterian sequence. Complex 4 was reserved for Upper Paleolithic levels of which no *in situ* traces were identified yet.

Erosion and colluvation regularly affected the Pleistocene deposits during transgression and regression phases. Major collapses of whole sediment packages are a typical phenomenon to be observed in spring-related sites (Butzer 1982; Jagher 2000; Le Tensorer et al. 2007). The tilting and partial dislocation of sediment complexes V4 to V6 at the base of the western Mousterian sequence were probably caused by weathering or tectonically induced instabilities. Displaced Mousterian deposits were found at the bottom of the well as massive sand deposits containing an abundance of lithic artifacts and faunal remains (Fig.14). The provenience of these extra-stratigraphic deposits is unclear; a possible correlation with the lower part of the western sequence, which shows several colluviations, is warranted; likely, a part of these sandy deposits could represent displaced archaeological levels stemming from the top of the Pleistocene sequence where a major hiatus exists between layer V1-1 and Holocene layer III. Different degrees of subsidence induced by sediment overburden, tectonic processes and recurrent aeration and drainage can be identified with layers showing abrupt distortions and micro-faults (Fig.15).

Site formation at Hummal appears complex and dynamic. It is hoped that future geomorphological investigations will provide additional information concerning the kind and energy of processes that were responsible for the current geometry of deposits. A first step into this direction is currently in progress with a three-dimensional modeling of the spring-site (Schuhmann 2007).

4.4 Major sediment types

The most common elements found in the Pleistocene deposits of Hummal are different types of carbonate. An overview of (bio-)chemical processes involved in lacustrine carbonate precipitation is given by Flügel (2004), Meyer (2001), Talbot & Allen (1996). A major component of the carbonatic sediments of Hummal is fine-grained calcite which forms the matrix of these lacustrine deposits. Stimulated by a removal of CO_2, the precipitation of micrite can be a by-product of microbial activity (photosynthesis) or evaporation of water masses (Flügel 2004; Freytet & Verrecchia 2002; Platt & Wright 1991). Concerning the site of Hummal, Meyer (2001) discusses several possible origins for the micrite which can be a product of biochemical precipitation and/or derived from the abrasion of the Cretacious bedrock. Given the high mineral content of the groundwater in El Kowm, she assumes that the calcitic mud precipitated in the course of increased evaporation during hot seasons. Another form of carbonate precipitation occurred in the source's littoral zone in shallow water and caused the successive growth of the spring mound. Microscopic analysis of littoral carbonates in Hummal resulted in a differentiation of several types depending on the size of calcite crystals, proportion and composition of detritus, and color (Meyer 2001). In many deposits, littoral carbonates are found as eroded debris which generated by weathering processes, and accumulated in a fine-grained calcitic matrix. The result is a detrital carbonate mud (LCD) with varying compositions and amounts of clastics. Aeolian sand and fragmented littoral carbonates are the most significant components of the detrital facies in Hummal. Meyer (2001) proposes a general model of LCD formation. Littoral carbonates weathered due to temperature fluctuations, plant growth or desiccation and debris accumulated within the pond or lake. In addition, depending on the time span of deposition and aridity, aeolian sand equally accumulates. Subsequently, high dynamic water flows lead to an admixture of the detritus with micrite and limnic elements (ostracodes, gastropods, algae) and a rounding of particles. The differentiation between LCD and a true colluvium (C) is problematic, and the latter is seen as a deposit which formed without water coverage, shows a higher content of detritus, lacks any stratification, and shows intensive precipitations of gypsum as well as iron-oxides. The differentiation between a colluvium and the EC-type of sediment is based on the lack of lacustrine material in the latter which consists exclusively of terrestrial debris. Nevertheless, both sediment types originated from colluviation.

In situ freshwater carbonates are equally present in the depositional sequence of Hummal. In contrast to littoral carbonates, their formation is correlated with high water coverage during periods of increased spring activity (Flügel 2004). Two principal variants are found in Hummal: freshwater carbonates (K, LC) and travertines (Meyer 2001). The former is a fine-grained, light grey colored carbonate showing pores of algae and including many ostracods. The travertines occur as several varieties depending on the degree of cementation. Although thin section analysis is still lacking, we can designate some of the freshwater carbonates as bioherms in the form of algal tufa which developed by calcite or aragonite precipitation, a process triggered by caynobacteria and algae (Flügel 2004; Pentecost & Viles 1994; Platt & Wright 1991). Evaporation during a warm climate induced the tufa's cementation which shows a high porosity and encrustation of aquatic plants. Another type of travertine is found as a massive, dense, and sometimes laminated deposit. Its density was probably caused by an uninterrupted growth of sparite which fills out existing pores completely (Meyer 2001). The most impressive travertine formation was found in the western part of Hummal with a thickness of over two meters and can presumably be seen as representing the rim of the spring mound in the upper part of the Pleistocene sequence. In many layers, travertine is encountered as clastics in different size. For the moment, we interpret certain EC-type deposits as weathered travertine spring domes of which the angular debris accumulated in cone-shaped fans (Fig.16).

The majority of carbonate deposits in the Mousterian sequence of Hummal are of the palustrine type. In the context of shallow water bodies, palustrine carbonates are typical sediments which reflect repeated sub-aerial exposure (Alonso-Zara 2003; Platt & Wright 1991; Talbot & Allen 1996). After a fall of the lake level, the carbonate mud is modified by pedogenic processes which lead to a reworking of the original micritic substrate. Characteristic features are mottling, iron oxides, gypsum, vertical root cavities, desiccation cracks, and induration. Depending on the length of sub-aerial exposure, organic remains are differently affected; the considerable loss of faunal remains in many Mousterian levels can in part be explained by changing water levels and the repeated aeration of archaeological levels.

Repeated and often rapid regressions and transgressions of the water level leads to the extension or retreat of the lake shoreline and thus results in complex lateral and vertical facies changes (Platt & Wright 1991). In the case of Hummal, this interplay which is principally governed by climate changes or tectonic processes is mirrored by several features. All over the depositional sequence, we frequently observed a succession of different carbonate types, sometimes in form of laminae less then a centimeter thick (Fig.17). The white colored freshwater carbonates rich in ostracods represent high water stands which lead to an extension of the lake system and an outward shift of the marginal zone. They are frequently interstratified with grey colored gypsitic carbonates which are indicators for a drop of the water level resulting in the sediment's desiccation and evaporation of groundwater: This process lead to a precipitation of gypsum crystals along fissures and pores (Meyer 2001). Provided that the sediment was sub-aerially exposed for a prolonged period, pedogenesis set on. Ancient soil formations can be identified by several features which occur in variable concentrations and significance depending on the soil's maturity. Traces of vegetation are found as root traces, calcified plant remains, and minuscule carbonized wood fragments. Together with mud cracks, clay accumulations, calcrete, iron oxides, manganese, charcoal flitters and coprolithes in some rare cases, the soil formations are easily recognized in the depositional sequence (Le Tensorer et al. 2007; Meyer 2001). However, most of the pedogenic horizons are poorly developed or destroyed by subsequent erosion. From an archaeological point of view, soil formations represent a valuable means to reconstruct Middle Paleolithic settlement strategies as most of them correlate with a high density of archaeological remains. Apparently, the source of Hummal, or at least the investigated part of it, seems to have been a preferred locality when vegetation was dense and the water table low.

Both in the western and southern part of Hummal, the Mousterian sequence reveals so called “laminated carbonate muds” (LL). These varve-like carbonate deposits show an alternation between white and grey colored beds and are possibly the result of seasonal species variation of algae and phytoplankton (Hager 2008; Meyer 2001; see also Platt & Wright 1991). The formation of these laminated carbonate muds normally occurs in the pelagial zone of deep lakes and can thus be taken as an indication for humid periods with increased water imput. Variation also occurred in relation to the source being a hydrologically open or closed system. Interrupts in spring activity presumably caused a spatial reduction of the lake system and ephemeral or perennial water bodies remained. An anoxic, swampy environment with brakish water emerged in the course of a stop in freshwater supply. The incomplete redox reaction and algae blooms left their trace in grey to green colored sediments which show an accumulation of clay and the precipitation of gypsum. A further increase in the salinity of the ephemeral water body can result in the formation of so called *sabkhas* with a low gradient and evaporitic sedimentation during marked dry periods (Talbot & Allen 1996; see Pümpin (2003) for a description of different *sabkha*-formations in El Kowm). In Hummal, impressive *sabkha*-formations (AV and AN-facies type) are found as dark green to black colored, clay-rich layers (7 and 10) showing an internal bedding and high density of organic material as well as wind-blown quartz sand. Analogous deposits were discovered at the base of the Mousterian sequence together with deflation surfaces.

A regular component of the lacustrine deposits in Hummal is wind-blown material, such as abraded quartz sand particles and clay pellets, especially in sediments which accumulated during arid periods. The lack of vegetation cover and a constant wind activity favored the erosion and subsequent accumulation of allochthonous aeolian material. An assessment of climatic conditions as well as sedimentation rate is possible with the relative amount of quartz sand in certain layers (Meyer 2001). In the Mousterian deposits, on average, quartz sand only accounts for 5-20% of the sediments’ composition and a rather rapid sedimentation rate can therefore be deduced.

Beach-like deposits called “littoral sands” (LS) were discovered in one section of the southern sequence in the form of sediments rich in carbonatic sand and quartz sand together with a multitude of gastropod shells (Hager 2008). The latter belong to two different species, *Melanopsis* and probably *Viviparus*, which are adapted to shallow water bodies in semi-arid environments. Wave attack lead to a rounding of particles and the accumulation of these gastropod shells, however, the deposits do not represent true gastropod sands, as the shells are mostly undamaged and the bulk of sediment matrix is composed of inorganic material. The littoral sands were subdued to several phases of sub-aerial exposure and drainage which lead to intensive iron oxide precipitations.

Organic remains can be subdivided into the remains of aquatic fauna and flora, like gastropods, ostracods, calcified remains of Characea (e.g. oogones), algae, and foraminifera, and terrestrial material, like wood, roots, charcoal, and coprolites. This sort of remains generally makes up only a small fraction of the sediment with percentages ranging from one to five percent. Occasionally, the proportion can be higher as in some clay beds found in the lower part of the southern sequence where organic material comprises 5-20% of the sediment.

4.5 The Pleistocene sequence in the western and southern section of Hummal

The current depositional sequence was analyzed and described on the basis of profiles cut in the western and southern part of the well (Fig. 18, Fig.19, Fig.20, Fig.21, Fig.22, Fig.23, Fig.24, Fig.25, Fig.26 and Fig.27). The eastern section with its long, north-south running profiles 3, 27, 46, and 57 delivered additional data, however, the upper part of the Pleistocene sequence has not been studied in detail yet. The distance between the western and eastern section is about 10 meters and a rough accordance of sediment complexes is given. Nevertheless, it is interesting to note that the volume of Mousterian deposits and the density of archaeological remains are considerably lower in the eastern part. This is probably due to the current state of investigation within different paleotopographical loci. The eastern Mousterian sequence is not included in the present study for two reasons. First, micromorphological and sedimentological analysis of the eastern deposits is still lacking. Second, modeling the depositional context is hampered by a lack of trenches running perpendicular to the north-south axis. Thus, the current two-dimensional picture is insufficient for a detailed east-west correlation of Mousterian deposits (see also Schuhmann 2007).

4.5.1 Sediment complex V1

The uppermost Pleistocene deposits of Hummal were removed by a major erosion process before or during the Holocene period. This is clearly visible by the disconformity between the colluvium in layer III and the uppermost Pleistocene deposits in complex V1 (Fig.20, Fig.21 and Fig.24). This stratigraphical gap appears in every excavated section so far. Probably the uppermost *in situ* Pleistocene deposit in Hummal is found in the south with level S-V1-1 at a mean depth of five meters below datum. Despite an intensive alteration caused by the deposit’s recurrent aeration and drainage, this layer can be attributed to the lacustrine type of carbonatic silt which is found repetitively all over the sequence in complex V1:

- southern section: layers S-V1-3, S-V1-4, S-V1-6, S-V1-8, and S-V1-10
- western section: layers V1-1, V1-2, V1-3, V1-6, and V1-8

These massive freshwater and littoral carbonate deposits precipitated during major transgressions of the water table. Limnic elements such as gastropods, ostracods, and sub-aquatic vegetation are further indicators for an increase in spring activity. Minor oscillations of the groundwater outlet are identified by changing amounts of detritus and quartzitic sand proportions. In the present state of analysis, the time span of these oscillations, which can be influenced by seasonality and/or short-term climatic changes (Talbot & Allen 1996), are unknown. The uppermost deposits in the western section are strongly altered by weathering, and characteristic feature are profound desiccation cracks filled with infiltrated, fine-grained material. The chaotic texture, presence of aligned angular limestone blocks and colluviation of deposits V1-1 and V1-2 could be seen as indications for cryoturbation and solifluction processes during a cold climatic period. This hypothesis is further corroborated by the identification of a platy structure resulting from freezing and thawing and the formation of ice lenses in pores in the uppermost carbonatic silt deposits found in profile P64 in trench W2 (Ismail-Meyer, personal communication 2007). Although the correlation of this deposit with layer V1-1 is not yet proven, these observations are indicators for cryoturbation and solifluction affecting the uppermost Pleistocene deposits in Hummal during cold climatic conditions (Van Vliet-Lanoë 1985).

Prolonged regressions of the water level and related pedogenic processes are evidenced by layers S-V1-5 and S-V1-7 in the south, and layers V1-5, V1-7, and V1-9 in the west. The evaporitic sedimentation, precipitation of iron oxides and manganese, and the accumulation of clay as well as wind-blown material are typical features of these palustrine carbonates. Furthermore, the density of archaeological remains is the highest in these layers. In the southern sequence, the base of complex V1 is composed of a thin and heavily weathered travertine formation which developed in the context of a shallow water body.

The uppermost Pleistocene depositional sequence clearly reflects a recurrent extension and retreat of the lake's shoreline depending on the volume of groundwater outlet. These fluctuations coincide with sub-littoral and littoral carbonate precipitation in the context of increased humidity as well as travertine formation or pedogenesis during arid periods (Fig.27). Successive weathering and erosion of littoral carbonates can be either correlated to seasonal fluctuations in temperature and rainfall or major climatic changes. At times, erosion seems to have been intense, and depending on the paleotopographical setting some deposits were significantly affected. Marshy environments were presumably the preferred setting for human occupations at the spring. Unfortunately, the occupational surfaces were exposed to weathering for extended periods and thus faunal remains are badly preserved

4.5.2 Sediment complex V2

The transition to the middle part of the Mousterian sequence is characterized by *in situ* freshwater carbonates and travertine formations which represent the edge of an open lake system with stands of Characea and algae, as well as many gastropods. Again, rapid low-scale oscillations of the water table caused a periodical input of clastic material (mainly weathered littoral carbonates and travertine debris) which were embedded in the micritic sediment, and wave attack lead to a significant rounding of particles in many layers. This assumption is further undermined by the observation of intensive iron oxide and manganese precipitations as an evidence of changing potentials for redox reaction. In the western section, thin laminae composed of carbonate clastics, gypsum, clay and quartz sand in layers V2-1, V2-2, and V2-3 evidence a repeated emergence of anoxic conditions and pedogenic modifications in the context of an ephemeral water body (Fig.17). Depending on the duration of these interrupts in freshwater supply, the carbonate-gypsum-clay facies are of variable thickness.

A major characteristic of complex V2 are microbial travertine formations which precipitated in shallow water. The fabric of these travertines is varying, ranging from dense structures with low porosity (layer S-V2-1 parts of layer V2-4, and layer V2-5) to highly porous fabrics (parts of layer S-V2-2 and S-V2-3). The latter can be designated as microbial travertines approaching a type of tufa whose precipitation was mainly induced by photosynthesizing vegetation in the littoral zone.

The lower part of complex V2 in the western section shows a succession of at least four intervals of siliclastic input (layers V2-4, V2-6, V2-10, and V2-12) intercalated with in situ carbonate precipitation. For the moment, we assume rapid changes of the water table and corresponding fluctuations in the energy regime to be responsible for this LCD-LC facies change (Fig.31). Regression phases saw the weathering of a nearby travertine formation and accumulation of angular debris together with Aeolian material in the remaining low-energy water body. Subsequent transgressions and correlating high-energy water flows caused a reworking of the sediment, leaving behind detrital carbonate mud with well rounded particles. The rising water table extended the lake’s shoreline and in situ carbonate precipitation set on, covering the LCD layers and thereby protecting them from further wave attack.

At least three archaeological levels with differing artifact densities are identifiable in complex V2. For the moment, it is unclear whether these occupational remains are strictly in situ or were displacement from adjacent areas. The latter hypothesis is more plausible for artifact concentrations found at the base of level 5BII and in level 5BIII with lithic objects exhibiting irregular orientations. Wave action is another factor that has to be taken into consideration.

4.5.3 Sediment complex V3

Unequivocal correlations between the western and southern section are no longer feasible below sediment complex V2. In the western part of Hummal, it is followed by a massive, colluviated carbonatic silt deposit. In the southern part, a long LC-LCD-LL sequence represents a period of increased humidity and the precipitation of freshwater carbonate in a low-energy environment. Five different facies were identified which are distinguishable on the basis of variable detritus proportions and micritic textures. Microscopic analysis detected a more or less horizontal bedding of thin, bright and dark colored strata which give the impression of a varve-like deposit in the lower part of complex V3. They probably record seasonal fluctuations of water content and microbial activity (Hager 2008). The carbonate deposit was at least once sub-aerially exposed resulting in an intensive pedogenic modification which is visible in layer S-V3-2. Minor regressions of the water table are evidenced by intensified redox reactions and subsequent precipitation of iron oxides. Due to the abundance of gastropods, ostracods, and calcified remains of *Characea*, it is assumed that the sedimentation principally occurred during a period of increased spring activity. The presence of well-rounded carbonate and quartz particles suggests a constant transportation of allochthonous clastics into the pond.

Increased spring activity seems to correlate with a low intensity of occupation or even absence of human frequentation. Thus, anthropogenic sediment components are scarce or absent, except for the base of complex V3 where a significant density of lithic artifacts and faunal remains were unearthed.

4.5.4 Sediment complex V4

In the southern section, this 10 to 20cm thick comprises two different facies: littoral sands which are found at the base and top and a laminated carbonate mud in between. The littoral sands can be used as a stratigraphic reference as they are found only in trench S1 and no comparable deposit has yet been unearthed in the remaining sequence of Hummal. They consist of carbonate and quartz sands and contain an abundance of gastropods as well as archaeological material. Micromorphological analysis suggests that the deposition of these sands occurred in the littoral zone during transgressions of the water table because of a high density of limnic elements (Hager 2008). Subsequent regressions and aeration caused an intensification of redox reaction which provoked iron oxide precipitation and enabled human occupations on these beach-like deposits. Micromorphological and sedimentological analysis of the littoral sands are contradicting concerning the dynamics of sedimentation. The preliminary sedimentological analysis postulates a high-energetic water flow during which fine-grained material remained in suspension, whereas micromorphological results suggest a low-energetic context of deposition. Future research will hopefully provide a more concluding answer to this question. The intercalated laminated carbonate mud with its plenteousness of ostracods, oogones and *Characea* remains precipitated in the context of a hydrologically open lake. The laminar bedding is probably the result of seasonal changes in humidity and temperature. During the initial accumulation of littoral sand a significant part of the underlying clay deposit was eroded, and therefore layer S-V4 is placed in disconformity over layer S-V5-1.

In the western part of the well, a 30 to 40cm thick succession of gypsitic clay beds is defined as complex V4. They have tentatively been attributed to the AV-facies despite a considerable amount of carbonate clastics. Sedimentological analysis of complex V4 is still lacking and we can therefore not provide a conclusive depositional model. However, the abundance of calcified plant remains and quartz sand, and the green to grey ranging colors, which are provoked by a partial oxidation or irons, give the impression of a swampy environment with ephemeral lakes and a dense vegetation cover during a dry period.

4.5.5 Sediment complex V5

More pronounced arid conditions caused a prolonged sub-arial exposure and pedogenic modification of the top of a massive colluviated carbonate deposit in the western section. The dark brown to green colored soil formation in layer V5-1 appeared as a highly porous sediment containing a considerable amount of gypsum, quartz sand as well as calcified plant remains; the quantity of carbonates is lower compared to overlying complex V4. The evaporitic character of sediment is further reinforced by intensive ion-oxide precipitations. The lower two third of the western complex V5 is massive colluvium which was reworked in the course of the pedogenesis forming on top of it.

In the southern section, many layers of the lowermost sediment complex S-V5 accumulated in a shallow, ephemeral or perennial water body with anoxic conditions and a swampy edge. Resulting deposits are detrital carbonate mud with a high amount of weathered littoral carbonates and black or dark-green colored clay accumulations rich in organic matter and quartzitic sand. Nevertheless, intermittent transgressions of the water table are identifiable, especially at the base of complex S-V5. The freshwater carbonates indicate a low-energetic depositional context in combination with a significant water cover. For the moment, it is unclear whether major climatic changes or only locally occurring processes were responsible for this alternation of different sediment types. A combination of both is the most plausible hypothesis. Oscillations between major dry and humid phases would explain the macroscopic transitions between limnic carbonatic silts and clay deposits representing *sabkha* formations. Microscopically visible laminae in some of the silt deposits are better explained by seasonal variations in humidity during which only minor shifts of littoral zone occurred. The alternation of grey-colored littoral carbonates with light-brown colored sub-littoral carbonates visible in layers S-V5-2 and S-V5-3 are respective indications. Pedological features were identified at the top of level S-V5-5 which was subsequently eroded. Intensive erosion processes which are presumably related to dissolution effects in the carbonatic substrate created channel-like depressions which subsequently served as areas of deposition. This phenomenon is observable at least from the deposition of layer 6B onwards and is responsible for the north-south oriented inclination of layers S-V5-7 to S-V5-2.

4.5.6 Sediment complex V6

In the western part, the stratigraphical investigations in 1999 identified layer V6 as the lowermost archaeological level being geologically *in situ*. The layer is composed of coarse siliclastics intermingled with littoral carbonate fragments and quartz sand, whereas a fine-grained matrix is missing. On the top of this colluvium, an eroded soil formation was reconstructed on the basis of remaining clay particles in pores and intensive iron oxide precipitations, giving the sediment its characteristic orange color.

4.5.7 Sediment complex V7

A sterile, 60cm thick succession of LCD and AV facies types was located in the northwestern part of trench W3. Complex V7 was truncated by the dislocation of overlying sediment complexes V4, V5, and V6. The thick clay accumulations in layers V7-2 and V7-4 presumably represent an interruption of carbonate precipitation caused by a stop in freshwater supply. Desiccation and evaporation of groundwater lead to the precipitation of gypsum crystals. The scarcity of Aeolian material is surprising, and it can be assumed that the regression phases were induced by local, tectonic processes rather than climatic factors. This aspect prevents us from a correlation of complex V7 with one of the *sebkha*-formations at the base of the southern sequence despite some similarities in sediment composition and texture.

4.5.8 Sediment complex V8

The base of the western sequence is formed by a massive, colluviated deposit. Microscoic analysis was able to identify several colluviation phases intercalated with *in situ* freshwater carbonate precipitations in the lower third of complex V8 (Meyer 2001). The upper part consists of a single colluvium which lacks any internal structure. Complex V8 directly overlies the Hummalian level 6a and eroded a significant part of it (Fig.18). Thus, in the present state of research, we lack any *in situ* transition from the Hummalian to the Mousterian.

4.6 Diagenetic processes

Pümpin (2003) gives a detailed overview of different kinds of weathering processes which typically occur in semi-arid environments and have been observed in the sequences of Nadouiyeh Aïn Askar and Hummal. For the present paper, we will shortly discuss the most significant diagenetic phenomena and their influence exerted on Mousterian deposits. Three principal kinds of weathering can be distinguished: physical weathering, chemical weathering, and biogenic diagenesis. All of them are related to each other in a complex interplay (Pümpin 2003).

Evaporitic sedimentation played a crucial role during periods of increased evaporation. The precipitation of evaporates is further increased by a periodic infiltration of the sediment with meteoric water. The volume increase exerted by the growth of salt minerals in fissures and pores caused the fragmentation of littoral carbonate deposits and subsequent colluviation of debris. Temperature fluctuations had a similar but probably minor influence. Possible cryoturbation effects were identified at the top of sediment complex V1 in the western sequence.

The chemical weathering in Hummal spans dissolution as well as accretion effects (Le Tensorer et al. 2007; Pümpin 2003). The dissolution of salt minerals and sulfates was ubiquitous in the semi-arid environment of the site. A striking dissolution phenomenon is the dedolimitization of flint which was initially identified on extremely corroded bifaces in the site of Nadaouiyeh Aïn Askar (Pümping 2003). The flint varieties, which can be found in the region of El Kowm, contain variable amounts of dolomite. Artifacts being made of dolomite-rich flint were seriously affected by this sort of dissolution and appear as white colored, chalky remains with a high porosity. Dedolomitization is triggered by an increasing pH value, and artifacts showing this kind of weathering were found all over the Mousterian sequence within gypsitic carbonate deposits representing an alkaline milieu (Fig.28, A); heavily corroded artifacts are rare (n = 16).

An accretion process is represented by the growth of authigenic quartz crystals and secondary deposition of SiO_2 around mineral grains. Authigenic quartz and secondary SiO_2 accumulation can be found in a significant number of Mousterian levels, however, a systematic quantitative assessment of these phenomena requires ongoing research. Accretion of secondary SiO_2 is also found on lithic artifacts which were embedded in an alkaline environment. Such conditions prevailed for example in the massive quartzitic sand accumulations found at the bottom of the well where thousands of artifacts exhibiting a distinct glossy patination were unearthed (Fig.28, B).

Biogenic weathering is largely an effect of animal activity and pedogenic processes. Bioturbation induced by burrowing rodents was identified in Holocene and uppermost Pleistocene deposits. A characteristic feature of sediment complexes V1 and V2 are deep shrinkage cracks filled with soft, brown colored sediment. It consists predominantly of material which stems from the metabolism of termites, root fragments and infiltrated clay minerals (Fig.29). As has already been described, pedogenic processes frequently alterated the carbonate deposits leading to a substantial reworking of the original sediment structure.

4.7 Human impact

As many other artesian springs in the El Kowm region, the source of Hummal has been exploited as a well since several hundreds if not thousands of years. For the moment, it is not possible to date the earliest well constructions, however, a few ceramic fragments found in sediment complexes II and III point at activities in proto-historic times, probably during the Chalcolithic period (Genequand, personal communication 2004). No construction features dating to that early period were identified so far. The well as it is visible today, was built within the last 100 years, including mud brick walls, stone walls, concrete walls, and irrigation channels. The latter are oriented towards the north and northwest. The northwestern channel which is visible in the picture taken in 1967 was found as a three to four meter deep and 50 centimeter wide structure cutting through the upper part of the Pleistocene sequence (Fig.20 and Fig.30). The gutter is made of concrete and the whole channel was filled with several beds of wind-blown dust. Due to a persistent water flow, the sediments in the channel’s vicinity were hydrologically altered and show an increased compaction as well as leaching.

The most drastic result of anthropogenic input is the well funnel itself. The dig for groundwater saw successive enlargements of the well, and thereby a significant part of the Paleolithic sequence was destroyed. A conservative estimate stays that at least $750m^3$ of Pleistocene sediments were removed in the course of well construction. The sharp contact zone between the conical-shaped well funnel and the *in situ* Mousterian sequence is visible in profiles (Fig.21 and Fig.25).

The constant pumping of water using motor pumps caused a rapid lowering of the groundwater table in recent years. Nowadays it is found in a depth of 40 to 60m whereas a few years ago it rested at 10 to 15m (Taha, personal communication, 2005). The rapid decrease of the groundwater table can exert substantial effects on deposits situated in the immediate surrounding of the well zone. Of particular mention is volume reduction, especially of plastic sediments, internal erosion and increasing gradient towards the center of the well. Determining the impact and calculating the secondary effects exerted by the extensive water pumping is currently being dealt with by a PhD project run by D. Schuhmann.

5 The Mousterian sequence and archaeological sample

In the present state of analysis, 39 archaeological levels have been identified in the Mousterian sequence of Hummal. This figure has to be seen as preliminary because of insecure facies correlations within and between the well's western and southern section and the limited extent of excavation, especially in the lower range. The stratigraphy in both areas shows a succession of archaeological deposits four to five meters thick (Fig.13, Fig.20, Fig.21, Fig.24 and Fig.25). Thus, the Hummal site is one of the rare cases that allows for a study of variability in technology and site use within one locality over a specific, albeit unknown, time span (Hauck et al. in press).

Across the western and southern sequences, the levels are variable as regards their archaeological potential and degree of disturbance. Tables 5 and 6 show that artifact densities vary by more than two orders of magnitude across the sequences; the range goes from 2965.5 to 1.0 objects per m^3 in level 5a2 and 5AI respectively. Clearly identifiable artifact concentrations alternate with diffuse scatters or isolated items in some deposits. Dense packages of archaeological material occur in the 5a and 5b complex of the western sequence and in their southern counterparts, as well as in levels 5DV and 5E (Fig.32 and Fig.33). They are intercalated by either sterile layers, colluviated deposits or rapidly accumulated carbonates which contain widely dispersed objects. The alternation between high- and low-density levels can be illustrated by a cross section through the southern Mousterian sequence (Fig.34). As regards the upper part of the western sequence, the differentiation of archaeological levels was a challenge due to the absence of clear-cut limits and sterile zones between them (Fig.35). Prolonged desiccation led to a considerable cementation of the carbonate deposits and thereby blurred subtle changes between different facies. In addition, bioturbation and the successive wetting and aeration of sediments further increased the complexity of find distribution patterns. Moreover, a careful excavation of archaeological remains embedded in a cement-like matrix is difficult and requires a constant control of level differentiation. Erroneous find attributions can therefore not be excluded, but we are confident that the archaeological samples that were taken for examination and the corresponding results that are presented here are the smallest possible units of analysis and come closest to reality.

Site-modification in the context of artesian springs can be intense (e.g. Butzer 1982), and the complexity of formation processes which were identified across the Mousterian sequence are explained in chapter 4. The archaeological levels testify to differential degrees of disturbance.

While some levels were colluviated and re-deposited due to instabilities in the karstic underground or marked fluctuations of the water table, other levels show only minor artifact displacement due to water percolation or wave effects, bioturbation, and the shrinking of sediments caused by evaporation. Dislocated Mousterian artifacts and faunal remains were discovered at various positions in the well's center within massive quartz sand deposits that were left by major sediment collapses (Fig.7 and Fig.14). Loosely distributed artifacts in irregular positions occur in colluviums which are in direct contact with the *in situ* Pleistocene sequence; examples are sediment complex III and layers 5d and 5h in the western section of Hummal. The assemblages recovered from these deposits are often mixed with material from over- or underlying levels. A significant number of archaeological levels were affected by erosion in the course of dynamic sedimentation processes or lack of sedimentation and prolonged exposure to weathering. The micromorphological examination of certain levels suggests a significant reworking and mixture of sediments, such as the detrital carbonate muds, in the course of pedogenesis, weathering, water flows and change between closed and open lake systems. From an archaeological point of view, it is important to know the effect these processes had on archaeological levels. Interestingly, the archaeological remains often lack evidence for a major disturbance, as will be shown in the section that follows. In the case of Hummal, the interpretation of site formation processes is sometimes contradictory, depending on which line of argument one is referring to.

The influence exerted by water flows and wave action is difficult to measure. Observations made in the field indicate that archaeological material was frequently deposited in the littoral zone and slightly moved thereafter. However, no significant horizontal alignments or sorting of objects according to size is observable. The effect of wave action was probably responsible for the significant rounding of small bone fragments in some levels and the high number of lithic artifacts which were deposited with their ventral face upward. In the present state of analysis, it is assumed that the more convex dorsal face of flakes offered a higher potential for mechanical forces, such as water flows, to act on the piece, which was subsequently turned and embedded in the soft micrite (Fig.36). Local clusters of archaeological objects next to voids are likely to be the result of water flows and successive alignments (Schick 1986).

Vertical displacements on the site are caused by several factors. Profound cracks, which are related to the shrinking of sediment volume due to evaporation, root growth and bioturbation, pervade the western section (Fig.29); to mention further is the effect of decompression caused by successive well-constructions since protohistoric times. The distances of artifact movement along these fissures are variable. Lithic items which were displaced over a considerable distance are identifiable by their patina being different from the *in situ* sample. Minor movements along the cracks or in areas of higher subsidence between them are responsible for the considerable overlapping of artifact distribution between levels, as can be seen in Figure 35. Levels reflecting a deposition of material in an unconsolidated matrix often reveal large faunal elements that sank deeper than surrounding objects of lighter weight. Additionally, trampling by humans and animals can cause a considerable vertical displacement of artifacts, especially in unconsolidated surfaces (e.g. Villa & Courtin 1983).

Despite these post-depositional disturbances, the majority of archaeological levels can be regarded as geologically *in situ* as they were rapidly covered by fine-grained sediments. Initial results from refitting studies underscore the assemblages' integrity. The majority of artifacts exhibit only slight patination, and mechanical damage is scarce. Exceptions are specimens found on deflation surfaces at the bottom of the sequence in levels 5g and 5F. These are intensely weathered and exhibit severe edge damage from trampling.

Whether dense artifact scatters are to be seen as remains of one prolonged occupation or several short-term frequentations is an open question. Identifying such palimpsests is at times extremely difficult if not impossible without distinctive spatial features (Dibble et al. 1997; Hietala 2003). If settlement hiatuses existed, they could not have been prolonged, however, as the patination on artifacts is always homogeneous. Moreover, rapid and continuous sedimentation led to the separation of some single occupation events. Micromorphological analyses are focusing on some of these questions. It is certainly no coincidence that high find densities frequently correlate with palustrine carbonate deposits and other sediment types which reflect a low water level. Contrarily, diffuse artifact scatters or isolated objects are mainly found in sediments which were deposited during periods of increased spring activity. It would probably be simplistic to state that the water level was the only triggering factor behind the variable intensities of human occupation. Nevertheless, we are convinced that the site's attractiveness was largely dependent on the quantity and diversity of local resources, which in turn were principally governed by spring activity. Hence, the preliminary model of Mousterian site-use is based on the interrelationship between find density and transgression or regression phases (see chapter 8).

In the following section, each archaeological level is described in detail in terms of depositional context, preservation, and find distribution. The relevant data are given in Tables 5 and 6.

5.1 The western Mousterian sequence

5.1.1 Archaeological level 5a2

Archaeological level 5a2 is the uppermost *in situ* deposit found so far in the western section of Hummal. Time constraints and an insufficient infrastructure forced us to excavate this level without a three-dimensional recording. A one-square-meter grid was established and allowed the collection of artifacts per square. Level 5a2 was encountered on an area of ca. $5m^2$ surrounded by the well infill in the southern and eastern excavation areas. It is a 15 to 20cm thick concentration of lithic artifacts within a detrital carbonate mud (Fig.20). On the small surface, 1611 lithic artifacts but no faunal remains were unearthed (Tab.5). Level 5a2 probably represents a Mousterian occupation at the spring during a short period of water regression. The high density of root traces indicates a dispersion of occupational remains in the intermittent riverine vegetation. Although we lack any direct evidence, we can assume that level 5a2 represents a relatively short period of deposition. This assumption is based on the thinness of level 5a2 and sedimentological observations, which point to a relatively rapid burial of archaeological remains (appendix B.2.5). Moreover, the lithics are well preserved and all exhibit the same weak patination.

5.1.2 Archaeological level 5a3

A dense concentration of lithic artifacts and faunal remains was found in the lower part of sedimentological complex V1 (Fig.32). The finds correlate with a poorly developed soil-formation in layer V1-7 and some objects were found vertically dispersed in the adjacent littoral carbonates V1-6 and V1-8. The current hypothesis states that humans occupied a marshy environment during a period of decreased spring activity. Corresponding remains became embedded in detrital mud, which was then overlain by a freshwater carbonate during the following water transgression.

Level 5a3 was excavated in 2003 on a surface measuring $12.5m^2$; the section was enlarged in 2005, thereby measuring $20m^2$. As the *in situ* Pleistocene sequence is truncated in its eastern and southern parts by the well funnel, the only means to examine the lateral extension of level 5a3 was to open new sections in the northern and western parts, adjacent to the 2003 excavation surface. These sections revealed a marked decrease in find densities, and it became clear that in the western part of Hummal only a small and probably marginal part of the original occupation zone is preserved (Fig.37). This impression is further reinforced by an increasing density of objects towards the southeastern excavation area, and thus it can be assumed that the densest part of level 5a3 was removed during the construction of the well.

The vertical distribution of finds shows a 20 to 30cm thick concentration of lithic and faunal remains with a twofold inclination of around 10° to the east and south. A remarkable inclination of around 45° is visible along the north-south axis in section Y=36.4 to Y=36.6 (Fig.37). Several causes for this phenomenon can be taken into consideration. It could be the result of stronger subsidence effects in the vicinity of the spring's outlet, leading to a drop-down of the southern part of level 5a3. However, underlying beds do not show the same phenomenon. An alternative hypothesis states that a major dislocation and re-deposition of level 5a3 caused this irregularity in vertical gradient. A massive travertine formation appeared directly below level 5a3 in the northern part from Y=36.5 onwards, probably representing an *in situ* littoral facies (see chapter 4.3). It is possible that the Mousterian occupation was originally located behind this travertine structure and that corresponding remains were dislocated due to a surface runoff, thereby literally falling over the rim. However, the lithic and faunal remains do not bear any traces of a major transport. Furthermore, the assemblage's composition and refittings indicate a rather undisturbed archaeological context. Nevertheless, minor post-depositional disturbances must be reckoned with. Three observations are relevant in this respect. First, the horizontal find distribution shows local clusters next to low-density areas (Fig.38). This phenomenon is not a reflection of former activity areas, but rather the result of wave action leading to an alignment of lithic and faunal remains. A second observation seems to corroborate this hypothesis. A significant number of lithic artifacts, especially the blanks, were found embedded with their ventral face upwards in the sediment. And finally, the detection of relatively large and deep ridges, especially in the funnel-near sections, and the fact that objects moved along these fissures, are further indications that parts of level 5a3 are strictly speaking not *in situ*.

Altogether we recorded 1436 lithic objects and 268 faunal remains in level 5a3. The great majority of lithic artifacts are well preserved, exhibiting a weak brown to red-colored patination and no edge damage. Potential intrusive elements are white, light grey and dark grey-colored pieces which together account for 10% of the total assemblage. The major part of the assemblage is made up of small lithic debris with a size below 2cm and originating from continuous core preparation and tool management (e.g. retouch flakes). The large amount of small debris leads to positive assumptions in two respects. First, we can count on a significant part of the reduction sequence being carried out on-site and therefore can take a closer look at corresponding technological aspects. Second, although doubts on the primary context of the finds cannot be ruled out with certainty, it is certain that there was no major disturbance or colluviation; otherwise, the small debris would be missing. Faunal elements are relatively well preserved. The majority show surface damage due to chemical diagenesis. Around many bones, calcareous crusts precipitated in the course of a repeated drying and wetting of deposit V1-5. A significant loss of faunal remains was caused by insect activity in the vicinity of large fissures.

5.1.3 Archaeological level 5a4

Archaeological level 5a4 was encountered directly below level 5a3 without a sterile intermediate zone. Therefore, it was possible to differentiate between the two levels only by a close examination of changes in the sediment type. This was all the more complicated as continuous desiccation had blurred the transition between these layers. A 6cm-thick concentration of archaeological remains was found embedded in an olive-green colored carbonate mud at the base of sediment complex V1 (Fig.20). Layer V1-9 indicates shortly prevailing marshy and oxygen-depleted conditions. The patchy distribution of layer V1-9 and the considerable gaps visible in the horizontal distribution of finds are presumably the result of intensive diagenetic processes which caused a considerable shrinking, partial erosion and vertical distortion of layer V1-9 (Fig.39). Responsible agents could be water percolation, desiccation, subsidence, and the formation of cracks. Portions of occupational remains survived in small depressions. During excavation, artifact clusters embedded in sediment lenses several centimeters thick were encountered next to areas devoid of any archaeological material. Nevertheless, if any mechanical forces affected the archaeological remains, they must have been of low energy as the lithic artifacts exhibit no signs of severe mechanical damage. Level 5a4 probably represents a similar environmental setting as was reconstructed for the overlying level 5a3. The spring fell more or less dry and intermittent vegetation developed in the littoral zone. Although the highest density of archaeological remains is found in squares A35 to E35, considerations as to where to locate the settlement’s core area are not warranted due to the limited excavation surface.

Lithic artifacts and faunal remains are well preserved and only 8% of all lithic artifacts show minor edge damage. Most of the pieces exhibit an orange-brown patination, caused by iron oxide residues. The oxygen-depleted milieu favored bone preservation, so that at least 75 bone fragments were recoverable. An outstanding discovery was an upper left human incisor, which shows typical Neanderthal traits (chapter 5.3.5).

5.1.4 Archaeological level 5b1

Archaeological level 5b1 was found embedded in a laminated carbonate mud that was easily identified in the field due to its distinct white color and low amount of detritus (Fig.20 and Fig.21). During excavation we were able to follow this level only up to the Y=35 axis. In the adjacent northern part of the excavated surface, the freshwater carbonate was no longer present due to erosion during the deposition of overlying layer V1-8. In the southern part, the silt contained well-preserved lithic artifacts and faunal remains (Fig.40). A clear differentiation between level 5b1 and underlying level 5b2 was at times problematic as the latter correlates with a thin clay accumulation that was hardly recognizable in a desiccated state. For this reason, Figure 40 depicts the extension of both layers. Techno-typological analysis of the lithic assemblage 5b1 is done only with artifacts that were unquestionably found in layer V2-1.

It is possible that shortly after the site's occupation, there was a relatively rapid rise of the water level, during which the remains were slightly moved by water flow; this could explain the higher number of edge-damaged artifacts compared to over- and underlying levels. Carbonate precipitation led to a rapid burial of archaeological remains; hence, level 5b1 is one of the few cases in which bones are well preserved, showing only a slight surface degradation.

5.1.5 Archaeological level 5b2

In layer V2-2, well preserved lithic artifacts and faunal remains were found within an olive-green colored deposit of thin clay. The clay bed is over- and underlain by laminated carbonate muds, and it is quite possible that layer V2-2 represents a more prolonged period of water regression and pedogenesis compared to the rapidly changing milieu represented by layers V2-1 and V2-3 (chapter 4.5). Its thickness varies between one and six centimeters in areas where the deposit was trapped in small depressions and therefore protected from erosion. This explains the irregular distribution of archaeological remains visible in Figure 40. In area ZZ-E / 33-35 only faint traces of layer V2-2 were visible, and no artifacts or animal bones were attributable to level 5b2.

The ecological setting of the Mousterian occupation, the remains of which are found in level 5b2, is probably comparable to that of level 5a4. The source probably fed a lake system, with its extension fluctuating according to seasonality. At times, drier periods left their mark and resulted in a more prolonged lowering of the water table. Consequently, the size of the lake decreased and littoral vegetation advanced towards the spring's outlet. This seems to have been the desired environmental background chosen by Mousterian hominids who settled inside the spring mound. During wetter conditions, sudden transgression of the water table lead to a partial erosion and significant alteration of the remaining pedogenic facies in which the archaeological remains are embedded. Successive precipitation of freshwater carbonates finally sealed the archaeological horizon and protected it from further destruction. The lithic artifacts are well preserved, showing a red-brown patination, and only a few items exhibit minor edge damage. As in level 5a4, the anoxic milieu favored the preservation of animal bones.

5.1.6 Archaeological level 5b3

Level 5b3 delivered the largest archaeological sample so far. Yet, with an artifact density of 660 objects per m^3, it is not the densest level in the Mousterian sequence. The level represents a rather diffuse concentration of objects with a vertical dimension spanning 30 to 40cm (Fig.41). The horizontal pattern of distribution shows no clusters, voids or any conspicuous alignments. It is highly likely that this concentration of archaeological remains does not represent a single moment of occupation, but rather a mixing of multiple site frequentations (Fig.33). Furthermore, several redeposition processes cannot be excluded. In the 2002 test excavation and in test pit W1, both located in the southernmost part of the western section, the level was identified as a single, 10 to 15cm thick concentration of artifacts embedded in a detrital carbonate mud. As we followed the level northward during the 2005-2006 excavations, it split into at least two separate layers (V2-4 and V2-6) with a sterile carbonatic silt bed (layer V2-5) in between (chapter 4.5.2; Fig.21). Accordingly, level 5b3 was subdivided into levels 5b3-1 and 5b3-2. If the depositional model outlined in chapter (chapter 4.5.2) holds true, level 5b3 is definitely not *in situ*. Examination of the vertical bearing shows that nearly all artifacts were found in a sub-horizontal position between 0 and 15 degrees, which accords with the general inclination of level 5b3 (Fig.42). In addition, no significant alignment patterns are discernible in the distribution of horizontal angles. Artifacts with a length axis smaller than 6cm were found randomly positioned on the excavation surface. Larger artifacts are overrepresented in a range between 30° and 105°; however, it is possible that the small size of the sample is responsible for this pattern. The horizontal and vertical bearing of artifacts speaks against a colluviation of level 5b3. Provided that level 5b3 represents a displaced and re-concentrated palimpsest, the mechanisms responsible for this process were of low force, as the lithic artifacts lack any signs of transport. During post-deposition, water flows caused the rolling of archaeological material; this can be inferred from the high number of small, well-rounded bone fragments. Subsequent aeration caused the precipitation of calcareous cement around bones. Despite these diagenetic factors, level 5b3 represents a homogeneous archaeological assemblage. Lithics of sub-level 5b3-1 and 5b3-2 exhibit the same patination and preservation and were thus lumped together for analysis.

5.1.7 Archaeological level 5b4

In between the freshwater carbonates of layers V2-7 and V2-9, a thin gipsitic clay accumulation, containing a few lithic artifacts, faunal remains and traces of charcoal, was identified. The distribution of archaeological material was found to be limited to the northern part of the excavation area (squares ZZ35 – E35); south of axis Y=35, level 5b4 was barely visible during surface excavation, and in test pits W1 and W3 it was encountered as an extremely thin and partially eroded layer (Fig.21). Level 5b4 presumably records a short-term occupation of a briefly exposed surface (during a single season?) within the spring mound. The site frequentation occurred during a generally wet period and a corresponding increase of spring activity. Hence it is possible that a significant part of level 5b4 was destroyed due to water turbulence.

5.1.8 Archaeological level 5b5

The lithic artifacts and faunal remains of level 5b5 were found embedded in a detrital carbonate mud (layer V2-10) that is very similar in composition and texture to the overlying level 5b3 (chapter 4.5.2, appendix B.2.10). Layer V2-10 consists of several travertine debris concentrations intercalated by fine-grained carbonatic silt. It has an average thickness of 15cm, but variation is significant, with archaeological remains having a maximum vertical extension of up to 50cm in some areas (Fig.43). The question concerning the depositional context of level 5b5 is not yet resolved. Two hypotheses are considered in the current state of research. As with level 5b3 (chapter 5.1.6), it is possible that the archaeological remains were re-deposited within successive debris flows involving the transport of travertine fragments and weathered littoral carbonates into the spring mound. Alternatively, it is also possible that humans frequented the site after the debris accumulation and settled directly on top of the colluviated material. In either case, the archaeological material was only slightly affected by post-depositional diagenesis under water cover; this led to a precipitation of calcareous cements around faunal remains and the rounding of small bone fragments. The horizontal distribution and bearing of artifacts and large animal bones does not show any signs of significant alignments which would have been the result of colluviation processes or the action of prolonged, high-dynamic water flows (Fig.43 and Fig.44). The horizontal distribution pattern appears arbitrary, and around 70% of all objects were found situated in a sub-horizontal position. A cross-section between square rows B and C shows the north-south extension of level 5b5 with an inclination of around 15° (Fig.43). Regarding patination, the lithic assemblage appears homogeneous. A significant proportion of artifacts exhibit a white patination provoked by intensive chemical weathering. The uniformity of patination and the low number of edge-damaged artifacts are further indications that level 5b5 was not significantly disturbed. Furthermore, the refitting of two scraper fragments which were found within a horizontal distance of 70cm corroborates the integrity of level 5b5.

The transition to overlying level 5b3 appears diffuse. Level 5b5 shows an abrupt termination at Y=35, where a major east-west running fault was located. We were not able to document the depth of this feature as excavations in the western section of Hummal ended in 2006. The gradient of levels 5b3 and 5b5 suggests that the northern part of the latter and overlying freshwater carbonates were truncated by the deposition of layer V2-6. The process of erosion and deposition is reconstructed with a simple model (Fig.31). Future excavations and geomorphological investigations in the western section of Hummal will test the plausibility of the proposed model.

5.1.9 Archaeological level 5b6

As level 5b6 was not fully excavated in 2006, its extension is unknown and specifications about the sedimentological context are premature. Altogether, 28 lithic artifacts and three faunal remains were discovered. They exhibit an orange-colored coating of iron oxides, which is an indication for a successive drainage and aeration of the sediment. Five out of 15 analyzed pieces exhibit a distinct white patination and a weathering of dolomite minerals. As iron-oxide precipitations are a typical component of clay-rich deposits in Hummal (Meyer 2001), it is possible that level 5b6 is associated with a thin clay accumulation which was not identified further south in trench W1. The sedimentological context is probably comparable to that of overlying levels 5b4 and 5b2. In some parts of the investigated area we already reached the underlying freshwater carbonate of layer V2-11.

5.1.10 Archaeological level 5b7

The succession of detrital carbonate muds and freshwater carbonates which were discovered in trench W1 contained at least five archaeological layers, of which level 5b7 is the lowest (Fig.21 and Fig.23). Lithic artifacts and faunal remains appeared in a 15 to 20cm thick deposit that shows a similar composition to overlying layers V2-10, V2-6 and V2-4. They all contain a high density of littoral carbonate clastics and travertine debris, as well as an abundance of archaeological remains. The restricted excavation surface in trench W1 did not allow for a comprehensive assessment of the level's gradient and extension. Yet we can assume a roughly comparable depositional context, as was reconstructed for levels 5b5 and 5b3 (chapter 4.5.2, appendix B.2.10; Fig.31). The sediment is composed of eroded carbonate clastics that accumulated in a micritic substrate. Subsequent oscillations of the water level caused a recurrence of the colluviation process and the truncation of prevailing deposits. It is unclear whether lithic artifacts and animal bones were re-deposited together with the weathering products or accumulated on top of the debris. Although the findings' position was not recorded in three dimensions, observations made in the field suggest that a major disturbance did not occur; no suspect alignment patterns of objects were identified. Moreover, the lithic artifacts and faunal remains are well preserved and only few lithics exhibit minor edge damage.

5.1.11 Archaeological levels 5c and 5d

Both levels were identified in 1999 while cutting profiles 4 and 6 (Fig.18). Any attempt to reinvestigate these levels in the course of later surface and test pit excavations was unsuccessful. A failure of correlation between local stratigraphies can be the result of facies changes in the western section. In the current state of research, it is possible that level 5c corresponds with level 5b5 or 5b7 and that level 5d corresponds with level 5b7 or 5e1. Since these correlations remain hypothetical, assemblages 5c and 5d are still treated as separate archaeological units. Furthermore, the lithic samples are too small to give any definite indication. All artifacts exhibit the same thick, light grey patination, and mixing of archaeological remains can therefore be excluded. Excavations in trench W1 which is located at a distance of around 10m to the west of profile 6 revealed a massive, reworked deposit, which delivered only a few isolated, differently patinated artifacts, below level 5b7. Although we designated this level as 5d it is fairly possible that it actually corresponds to a sequence of colluviated deposits which are located at the base of the western section and would therefore represent the top of level 5h.

5.1.12 Archaeological levels 5e and 5f

Both levels were discovered in 1999 during the cut of profiles 4 and 6 (Fig.18) and were described as a succession of several archaeological horizons within clayey detrital silt deposits (Le Tensorer 2004). The lithic samples obtained from profiles 4 and 6 were small, and hence, a techno-typological characterization was not possible at that time. Hence, to define the Mousterian variability in Hummal required an enlargement of the lower levels' sample size. As the Mousterian sequence is several meters thick, we were not able to achieve this aim in a reasonable time-frame by regular surface excavations. Therefore, a trench (W3) was cut in 2006 adjacent to profile 4 (Fig.8). Time constraints and the immediate need for analyzable artifacts prompted us to excavate it rapidly within a few weeks, without a three-dimensional recording of findings.

The 5e assemblage was found in sediment complex V4, which is composed of at least three clayey silt deposits rich in detritus (Fig.22). These palustrine carbonates reflect several pedogenic processes, and the distribution of lithic artifacts within all layers suggests that the spring was repeatedly visited during moments of low water level. The surfaces were sub-aerially exposed for a prolonged period, which explains the lack of faunal remains and the trampling features visible on some of the artifacts. All artifacts in levels 5e exhibit the same thick grey to light brown patination, which is probably a further indication for rather slow rates of sedimentation. Roughly similar environmental conditions can be reconstructed for the succession of at least three archaeological levels which were found in the underlying sediment complex V5 (Fig.22). As in level 5e, only the most robust faunal elements, such as tooth fragments, are preserved. Three archaeological horizons (5f1, 5f2 and 5f3) were found vertically segregated by sterile zones in between. Artifact densities are very low, especially in level 5f3.

The geometry of complexes V4 and V5, visible in Figures 20 and 22, is probably the result of instabilities near the spring's outlet that caused the tilting and subsequent displacement of the lower Mousterian sequence. Archaeological remains were certainly affected by these processes; however, the internal distribution of objects within each level seems to have remained more or less intact. Artifacts were encountered in a horizontal position and the persistence of small debris argues against internal erosion or colluviation. Trench W3 probably covered the remaining parts of complexes V4 and V5 and this explains why they were not encountered further west in trench W1.

5.1.13 Archaeological level 5g

In 1999, level 5g was identified as a distinct archaeological horizon with a high artifact density at the base of the western Mousterian sequence (Fig.18). Artifacts appeared within a loosely sorted deposit consisting of quartz sand and rounded carbonate clastics. The layer is easily identified due to the ferruginous coatings around quartz and carbonate particles, as well as lithic artifacts. The prospect of excavating level 5g on a larger scale in trench W1 and trench W3 turned out not to be feasible, as it belonged to the collapsed sediment complex V4-V6 (Fig.20). The level was severely affected by erosion, and only a small remnant can be found between -8m and -8.5m below datum. It is no longer present further west from X=105 onwards; in trench W1 only a small 20 x 20cm-sized pocket of level 5g was identified. The layer seems to have been intensively reworked in the course of a water flow and a subsequent pedogenic process. Moreover, the irregular position of findings, the high number of edge-damaged lithic artifacts and their heterogeneous patination are signs for a disturbed archaeological context. We therefore qualify level 5g as a palimpsest containing remains of more than one site frequentation. It is possible that they accumulated over a long time period. Faunal remains were protected against degradation through the precipitation of calcareous crusts that precipitated during recurrent cycles of watering and aeration.

5.2 The southern Mousterian sequence

5.2.1 Archaeological level 5AI

Level 5AI comprises at least three different layers (S-V1-1, S-V1-2 and S-V1-3), which represent the top of the southern Pleistocene sequence (Fig.24). Within this section, which attains 80cm in some parts, a few widely dispersed artifacts (n=10) were recorded. Faunal remains are absent and were probably destroyed due to multiple diagenetic factors affecting the deposits close to the modern-day surface; the same phenomenon was found with level 5a1 in the western section. Based on the fact that archaeological material is frequently found in the context of palustrine carbonate formations, it is possible that the findings of level 5AI correlate with S-V1-2 and S-V1-3-2.

5.2.2 Archaeological level 5AII

Archaeological level 5AII correlates with a detrital carbonate mud that bears evidence for evaporitic sedimentation (Fig.24 and Fig.27). The palustrine carbonate, with an average thickness of 20cm, reveals evidence for a dense vegetation cover along the littoral zone (appendix B.3.1). This environmental setting seems to have attracted humans, as a rather dense scatter of lithic artifacts was discovered in the eastern part of the excavated area in trenches S2 and S3. Further west, the find density thins out; the area of Mousterian occupation is therefore located in the southeastern part of Hummal. Nevertheless, this find density distribution could also be the result of erosion processes that affected some areas more strongly than others (chapter 4.5.2). The finds appeared in a sub-horizontal position, and level 5AII shows no signs of disturbance. Faunal remains are badly preserved, with the majority being identified as differently colored patches within the grey-green sediment; only one bone fragment was recovered. The lithics are well preserved and exhibit a distinct patina, ranging from light grey to white. The patination appears irregular and forms net-like patterns and stains on the lithics. In the present state of analysis, the responsible factors for this patterning are unknown; it seems that the patina is caused by microfissures on the artifacts' surface.

5.2.3 Archaeological level 5AIII

A 10cm-thick low-density artifact scatter was located within a strongly cemented sub-layer of layer S-V1-6, which consists of carbonate silts rich in detritus. The pedogenic alteration of overlying layer S-V1-5 left its mark in form of manganese and iron oxide precipitations along the dense, net-like pattern of root traces. The lithic artifacts show the same light grey patina as their counterparts in level 5AII. Their horizontal distribution is irregular, with considerable voids between areas of higher density (Fig.45). Although the problem of level identification during excavation can be responsible for this pattern, it is rather assumed that the investigated section covers the lakeward, peripheral area of a Mousterian occupation that was affected by wave action. The lack of faunal material cannot be explained by unfavorable preservation, as the carbonate silts contain many limnic elements and suggest a rather rapid sedimentation rate during a major transgression phase. It is possible that the exploitation of faunal resources was the not the reason why humans frequented the spring. The fact that the reconstructed lithic organization of level 5AIII points to a short-term visit, for which a stock of already reduced cores was imported, can be taken as an indication of special tasks that were performed, presumably focusing on vegetal material and drinking water.

5.2.4 Archaeological level 5AIV

Archaeological level 5AIV is quite similar to the overlying level 5AII in terms of sedimentological context and artifact preservation. Lithic artifacts and a few faunal remains were unearthed in a 7-10cm thick gypsitic clay deposit, which represents a major pedogenic process. Corresponding layer S-V1-7 was located in a sub-horizontal position at a depth of around -6m below datum (Fig.24 and Fig.27). Evidence of evaporitic sedimentation indicates a prolonged sub-aerial exposure of the carbonatic substrate, and the density of root traces in underlying layer S-V1-8 show that the lake system probably decreased to a marshy pond, constituting the local setting for a longer period. The lithic artifacts, found in high density dispersed all over the excavated surface, are the remainder of one or several site frequentations (Fig.46). Level 5AIV shows an upward gradient in trench S3 and was probably truncated further east during the deposition of the overlying detrital carbonate in layer S-V1-6.

Organic matter decayed due to intensive chemical diagenesis and faunal remains were only identified as faint traces. The lithic artifacts were found well preserved; their sub-horizontal position, their homogeneous patination, the small number of edge-damaged pieces, and the presence of small debris are taken as an indication for an undisturbed archaeological context. Post-depositional movement of objects over minor distances cannot be excluded and was presumably responsible for the artifact clusters visible in Figure 46.

5.2.5 Archaeological level 5AV

Archaeological remains which correlate with the massive detrital carbonate deposit of layer S-V1-8 were only found in the eastern half of the excavated surface. Level 5AV was not identified in trench S1 and from X=110 eastwards in trench S3. The reasons for this spatially restricted distribution of findings are unknown; preliminary sedimentological analysis reveals no indication of erosion processes. The level's western and eastern limits appear diffuse and a clear differentiation between level 5AV and underlaying level 5AVI is problematic. The reason for this difficulty is that both levels show a similar sedimentological context and the degree of cementation is the only distinguishing feature between the two. Further sedimentological and micro-morphological investigations are needed to better evaluate the context of deposition of both levels and to examine whether they actually represent a single archaeological deposit. The lithic artifacts are well preserved and exhibit the same light grey, irregular patination as the artifacts of overlying levels. Traces of iron and manganese oxides were caused by water percolation and aeration along root traces related to the soil formation identified in layer S-V1-7. The bioturbation of level 5AV is the explaining factor for the poor preservation of animal bones, and only a few robust elements were recoverable during excavation.

5.2.6 Archaeological level 5AVI

Level 5AVI correlates with a 20cm-thick travertine formation that was located in the western part of the excavated section. The travertine is very prominent in trench S1, whereas further east, it was encountered as local concentrations of clastics in trench S3. The distribution of archaeological remains correlates with the extension of the travertine formation, and level 5AVI was therefore not identified in trench S3. The find density was low, and the few lithic artifacts and well-preserved faunal remains were discovered as clusters within the tuff-like carbonate deposit. The clustering and irregular position of findings suggests that the archaeological material was significantly moved by wave action. This observation is corroborated by the nature of the sediment, which suggests that deposition occurred within a littoral facies that was intensively altered by a rapidly oscillating water table. Furthermore, the low amount of small debris is an indication that a sorting of objects according to size occurred to some extent.

5.2.7 Archaeological level 5BI

The archaeological level was encountered in a cemented freshwater carbonate containing a low amount of terrestrial detritus. The rapid burial of archaeological remains and their embedding in a soft, chalky substrate favored their perfect preservation up to the present day. Moreover, the deposit shows no signs for a significant reworking through pedogenesis and bioturbation. Faunal remains and lithic artifacts were found well preserved, and the patina on the lithics was weaker than in overlying levels. Level 5BI was excavated in trench S1 and S3 and on a limited surface (D) between the two (Fig.47). While a rather loose artifact scatter was found in trench S1 and surface D, a remarkable artifact cluster was discovered in trench S3. It comprised many long bone shafts of large herbivores, Levallois blanks and core trimming elements, and a few travertine pebbles that may be of natural origin. Given the perfect preservation of level 5BI, it is possible that this find concentration represents a special activity locus. This assumption has to be verified by an extension of the excavated surface and a detailed examination of the faunal remains and lithics to see whether a direct association can be discerned between these findings; the lithic sample is not analyzed yet and will be tested for possible refittings.

5.2.8 Archaeological level 5BII

The transition between levels 5BI and 5BII is subtle, with the facies change consisting of an increase in terrestrial detritus and porosity. Well-preserved artifacts and rather poorly preserved faunal remains were found embedded in a cemented littoral carbonate deposit that had been strongly altered by a changing water table and the growth of aquatic plants. It is unclear to what extent the spatial relation of archaeological remains was affected by the changing milieu. The finds' horizontal and vertical bearing does not reveal any suspicious alignments that could suggest wave action. However, some lithic artifacts were encountered in an upright position. It is therefore difficult to interpret the clustering of archaeological remains identified in trench S1 and trench S3 (Fig.48).

The trench S3 cluster was located in exactly the same position as was the artifact concentration in the overlying level 5BI. This could be seen as an indication for the presence of palimpsests in levels 5BI and 5BII, such palimpsests stemming from several occupations during which some areas were repeatedly frequented to perform certain tasks. The trench S1 cluster is interesting as regards the density of charcoal remains. It is fairly likely that they represent displaced remnants of a former hearth. The faunal remains exhibit a high degree of surface degradation, which is the result of increased microbial activity in an oxygen-rich environment. An increased redox potential is also evidenced by areas showing intensive iron oxide precipitation.

5.2.9 Archaeological level 5BIII

The depositional context of level 5BIII is nearly identical to the one recorded for overlying level 5BII. The sole difference is a higher input of terrestrial detritus and stronger weathering of the littoral carbonate deposit. Level 5BIII was only excavated in trench S1, as the 2009 excavation on the adjacent surface D and in trench S3 stopped at the transition between layer 5BII and 5BIII. Observations made in trench S1 show that the animal bones appear strongly degraded due to successive phases of watering and aeration in the course of a changing water table. The lithic artifacts are well preserved and show no traces of transportation by water. The surface of a few pieces was significantly affected by dedolomitization, which can be taken as indication that the archaeological material was at times embedded within an alkaline milieu.

5.2.10 Archaeological levels 5DI to 5DV

Archaeological complex 5D is described together because the first four levels 5DI-5DIV revealed only a few dislocated lithic artifacts and faunal remains, whereas a higher density of finds was discovered at its base in level 5DV. Complex 5D is about 70cm thick and consists primarily of an *in situ* freshwater carbonate which precipitated in a rather calm, oxygen-rich lake environment (Fig.24 and Fig.25). Several regression phases are identifiable as thin accumulations of terrestrial detritus, travertinized beds, iron oxide precipitations, poorly developed soil formations and thin laminae of differently sized calcite crystals at the base.

Level 5DI cannot be considered as an archaeological level, as the remains found at its top actually belong to overlying level 5BIII. In levels 5DII, 5DIII and 5DIV, a few widely dispersed lithic artifacts (n=8) and faunal remains (n=6) were discovered. Moreover, the sediment is devoid of small lithic debris. These observations suggest that the findings represent displaced items from occupation areas the location of which is yet unknown. As the freshwater carbonate reflects a generally extended lake system, it is possible that the excavated section does not cover the zone of occupation, which was presumably located farther away. The higher find density in level 5DV suggests the frequentation of Hummal during a period in which the spring activity was governed by seasonal changes in climate. The evidence of eolian components and intensified redox reactions shows that the sub-littoral carbonate periodically fell dry; it is likely that Mousterian hominids settled on the exposed surface during a period of low water table. The perfect preservation of lithic artifacts and faunal remains indicates that they were rapidly buried by precipitated micrite. Although the small size of the excavated section does not allow a comprehensive assessment of site formation processes, the sub-horizontal position of all findings lets us assume that no major post-depositional disturbance occurred.

5.2.11 Archaeological level 5E

Level 5E comprises the remains of at least two site frequentations during which humans settled on a beach-like deposit. The latter consists of an abundance of gastropods, carbonate clastics and quartzitic sands. The fact that this littoral sand facies is intercalated by a laminated carbonate mud suggests that a considerable fluctuation of the water table occurred; the rate and dynamics of sedimentation are not yet clear, owing to conflicting results from micromorphological and sedimentological analysis (chapter 4.5.4). Although the window opened in section S1 is small, level 5E can be considered as the one of the richest and best-preserved archaeological horizons in the southern part of Hummal (Fig.49). The dense, 20cm-thick concentration is located at a depth of -8m below datum. The lithic artifacts, faunal remains and charcoal fragments are found in a sub-horizontal position and the horizontal distribution shows no suspicious alignment or clustering of objects. Find density thins out in squares X:100-102 / Y: 16-17, which are nearest to the Holocene colluvium and modern well infill. It is possible that the well's construction and use led to a disturbance of archaeological levels near the funnel, or that parts of the occupation surface were already displaced in Pleistocene times. Nevertheless, we can assume that level 5AIV represents an *in situ* situation and that the opening of a larger surface will allow for an examination of the functional relationship between lithic artifacts and faunal remains. The level's integrity is further evidenced by the discovery of five vertebra of a large camel in anatomical connection at the transition between level 5E and the underlaying level 5FI.

5.2.12 Archaeological levels 5FI to 5FVII

The detrital muds and *sabkha* formations at the base of the southern sequence revealed only loose scatters of lithic artifacts and poorly preserved faunal remains. The lithic artifacts exhibit different patinas and severe edge damage. The weathered and damaged artifacts occur either within the dark-colored, clayey *sabkha* formations or in freshwater carbonates. Given these features and the fact that the objects are found in irregular positions, it is highly likely that archaeological complex 5F comprises palimpsests that were deposited on deflation surfaces. Subsequent water transgressions displaced parts of the archaeological material and re-embedded them under water within a micritic substrate. The edge damage of lithic artifacts is probably the result of repeated trampling by animals which gathered at the waterhole during times of increased aridity.

5.3 Not just lithics - Organic remains and animal bones

Due to their imperishability, stone artifacts constitute the largest part of the archaeological sample. The lithic assemblages were taken for a detailed techno-typological analysis, the result of which is presented in chapters 6 and 8. In addition, a catalogue of all assemblages is presented in annex A. Given the multitude and intensity of diagenetic process that affected the Mousterian deposits, it is not surprising that organic remains are scarce. The quantity of recovered faunal remains is shown in Tables 5 and 6, and their significance as regards the reconstruction of site use are discussed, together with taphonomic aspects, in sections 5.3.2 and 5.3.4. Charcoal was frequently found in the form of small flitters, whereas larger fragments which are suitable for a paleobotanical analysis are extremely rare. Such fragments were observed in levels 5a3, 5a4, 5b1, 5BII, 5b3, 5b5, and 5E. Microscopic analysis shows that at least some of them are attributable to deciduous trees (Hager 2008). Together with burnt lithic artifacts and bones, the charcoal remains represent traces of former fireplaces. However, no distinct spatial clusters of heated material, which would allow a reconstruction of hearths, have yet been identified.

A remarkable discovery was made in 2007 during excavation of level 5AIV in the southern part of Hummal. After removing a Levallois blank, a clearly visible black spot was recognized in the negative it left in the sediment. The black substance was found to be restricted to the proximal part of the flake’s dorsal surface (Fig.50). After the flake had been sampled together with surrounding sediment, it was handed to the *Laboratoire de biogéochimie moléculaire* of the University of Strasbourg for chemical analysis. Although the analysis is not yet completed, preliminary results suggest that the substance is natural bitumen that was used for hafting the flake. A re-examination of artifact collections which stem from colluviated deposits in the center of the well revealed two more artifacts on which a comparable substance was found attached. As soon as definite results are available, these findings and their significance will be discussed in more detail.

5.3.1 The faunal assemblages of the Hummal Mousterian

Analysis of the faunal remains contributes substantial information on the ecological setting of the site and the way prehistoric humans used the locality. In combination with the lithic data, it is possible to reconstruct strategies of animal food procurement and consumption and the influence this resource exerted on the settlement pattern of Middle Palaeolithic foragers in El Kowm. Unlike those in many other open-air sites of the Levant, the animal bones in most of the Pleistocene deposits of Hummal were preserved due to a rapid sedimentation and a carbonate-rich environment (White & Hannus 1983).

A comprehensive insight into the exploitation of animal resources by Mousterian hominids at Hummal is severely hampered, however, by first- and second-order changes to the faunal remains. Destruction of organic tissue due to natural forces, such as weathering and transport, is especially pronounced in open-air sites, of which the artesian spring of Hummal is just one example. A filter on the second-order is posed by the circumstances of fieldwork. The majority of excavated deposits have not yet been sieved, owing to an insufficient infrastructure and time constraints. Although excavations on the site produced a relatively large faunal sample that covers the whole Palaeolithic sequence, a systematic archaeozoological analysis is still to be done. Since 1997 all animal remains have been collected, prepared and roughly examined following a paleontological approach, with the restoration and analysis of faunal and human remains being directed by P. Schmid, Institute and Museum of Anthropology, University of Zurich. A first and preliminary attempt to determine taphonomic processes and archaeozoological key features was conducted by R. Frosdick of the Institute for Prehistory and Archaeological Science, Basel University, over a period of two weeks in 2009.

5.3.2 Taphonomy

The major taphonomic agents that affected the faunal remains at Hummal are mainly of a post-depositional nature. As the site represents a constantly open system, it faced significant fluctuations in water content, aeration, salinity, pH value, and microbial activity, as well as anthropogenic input (chapter 4). It is known that, depending on the rate of sediment accumulation and the burial environment, animal bones are differentially affected by destructive forces (Nielsen-Marsh & Hedges 2000; Hedges 2002; Stiner 2002).[8] Figure 50 shows the proportion of animal bones in archaeological samples from across the Mousterian sequence of Hummal. Percentages over 50% are only found in the smallest assemblages and are certainly the result of sample size error. In general, the amount of faunal remains comprises between 10% and 30%. It follows that, given the relatively small proportions of faunal remains compared to lithic artifacts, we have to reckon with a considerable loss of bone material. The lack of faunal material in levels 5AI, 5AII, 5AIII, 5a1 and 5a2 is owing to a bad preservation of organic tissue in these deposits, which are the closest to the modern-day surface. It is likely that unfavorable conditions of preservation are attested for the lowest Mousterian levels 5e to

[8] Strikingly, the conditions of preservation seem to be significantly better in the upper Mousterian complex of the neighboring well-site Umm El Tlel (Boëda et al. 2001). This difference shows that site formation processes and diagenetic effects can be markedly different from site to site within the El Kowm area, despite a common environmental and depositional context.

5g in the western sequence. These levels reflect well-developed soil formations and long periods of sub-aerial exposure. Thus, a significant amount of animal bones was prone to decay prior to the archaeological levels' burial with carbonate micrite. In the present state of analysis, it is impossible to assess the degree of material loss. However, the state of preservation in most levels, the composition of faunal assemblages, and the intensity of degradation, all suggest that the loss is considerable.

The composition of the Mousterian faunal assemblages reveals a prevalence of the densest parts, such as teeth, phalanges, sesmoids, carpals, tarsals, and diaphysis fragments (Frosdick, personal communication 2009). This bias can be seen as a density-mediated form of taphonomic destruction, which results in a major loss of those skeletal elements with a lesser resistance to chemical and physical weathering (Lyman 1984). Moreover, the overrepresentation of shaft fragments, and the proximal articulation of radius and distal articulation of tibia, suggest that fragmentation followed the density gradient (Andrews 1995; Klein & Cruz-Uribe 1984; Stiner 2002). A characteristic taphonomic feature in Hummal is the bones' surface degradation, which was probably caused by the dissolution of minerals, itself resulting from microbial action and root etching (Hedges 2002; Reitz & Wing 2008). Micro-organisms play a crucial role in bone degradation, and are probably more influential in this respect than the soil chemistry (Nicholson 1996). Surface damage is especially frequent in levels that have faced extended periods of wetting and drying and the formation of cracks in combination with root and termite activity. Therefore, archaeological complexes 5a and 5b in the western section evidence a higher degree of bone surface degradation than, for example, levels 5DV and 5E in the southern section (Fig.52). Changing pH values provoked by intermittent fluctuations between a wet and a dry environment constitute another critical factor for bone preservation (Nielsen-Marsh & Hedges 2000). The rising alkalinity in the context of pedogenic deposits caused an increased rate of bone destruction. This is the case in levels 5a2, 5e, 5f1 and 5f2/3, where only a few high-density fragments were unearthed. The majority of faunal remains underwent several phases of wetting and drying, especially those elements which were buried in detrital carbonate deposits. Originally accumulated on a dry surface, the faunal remains were, in the worst of all cases, colluviated and re-deposited within the water body of the source together with the lithic material. Subsequent oscillations of the water table frequently caused a renewed sub-aerial exposure of the sediment and its pedogenic modification, depending on the length of exposure. Buried remains equally underwent a constant drying and wetting within the sediment body. Apart from destruction, features which evidence the negative effect of wetting vs. aeration of bone material are orange-to-dark-brown discolorations and mineral encrustations.

Further research is needed in order to qualify and quantify these taphonomic features in relation to specific sediment types. Bones which were buried in the littoral zone exhibit a slight edge rounding due to wave attack. The smaller the element, the higher is the degree of edge abrasion due to water flows. Fragments with a size below 1cm are frequently found as spherical sediment particles. However, in contrast to the significant surface degradation, the rounding of edges is less pronounced and can be seen as an indication for a low degree of post-depositional movement. This corroborates the impression which was already gained from the preservation of the lithic material (chapter 5.1 and chapter 5.2).

About 2% of the bone material exhibits traces of carnivore gnawing. Given the significant surface degradation of bones, this figure has to be taken with caution. Moreover, due to the low sample size in each level, it is not possible to specify particular moments in the time range of Mousterian occupations during which body part accumulations were significantly affected by carnivore activity. However, the scarcity of traces of gnawing and the absence of carnivore remains in the Mousterian levels of Hummal, indicate that at least a large proportion of ungulate bones stems from hunting by humans.

5.3.3 Identified species

Due to the mentioned diagenetic factors, the Mousterian faunal sample is biased towards large-bodied species. Small animals, like rodents or birds, are represented by only one fragment each. Over 1000 animal bones were recorded in three dimensions. This sample is completed with several hundred remains recovered in test trenches. About 30% of the faunal material was found in such bad condition that a recovery was no longer possible. Over 75% of the excavated and restored sample was analyzed. Figure 53 shows the size of analyzed samples in selected Mousterian levels. It is obvious that because of the small sample size in the majority of levels, meaningful interpretations can only be done for 9 out of 24 assemblages. The classification according to species is given in Table 7. Among the identifiable group of animal bones, a distinct predominance of camel is visible in each level. The ungulate sample is completed by remains of gazelle, equids and bovids in decreasing frequency; eggshells of *Struthio camelus* were discovered in levels 5b1 and 5E. As already mentioned, the given frequency distribution of species is certainly biased by differential degrees of degradation, however, the homogeneous distribution of arid grassland ungulates across the Mousterian sequence can be seen as a characteristic feature of the Mousterian sequence in Hummal. Remains of the genus *Camelus* can be attributed to the dromedary. The predominance of *Camelus dromedarius* in the Mousterian of Hummal is probably not exclusively the result of taphonomic effects, but also reflects a targeted exploitation of this animal. Interestingly, the camel remains belong not only to *Camelus dromedarius*, but also to a hitherto unknown species that stands out by its markedly large body-size. This giant camel form apparently coexisted with *C. dromedarius*, and is evidenced by over 30 postcranial and cranial elements, including teeth. Their size exceeds those of the “normal” dromedary at least 1.5 to two times (Fig.54). Despite some affinities with *Camelus thomasii*, we have decided to separately describe and label this species as *Camelus moreli* (Le Tensorer et al. in prep.).

The dominance of camelids, equids and gazelles as well as rare finds of *Struthio camelus* are characteristic for a faunal assemblage adapted to a steppe environment; similar compositions were discovered in the neighboring Mousterian sites of Umm El Tlel (Griggo 1998a, 1998b; Boëda et al. 1998, 2001) and the Douara Cave in the Palmyra region (Payne 1983; Akazawa 1996). This steppic label is radically different from synchronous faunal assemblages found in Mousterian sites within the woodland Mediterranean coastal area (e.g. Stiner 2005; Speth & Tchernov 1998). Given this discrepancy, which was probably accompanied by different hunting strategies (Shea 1998), the technological homogeneity on a general level regarding Levallois blank production between sites of the Mediterranean coastal area and sites located in the Irano-Turanian desert is all the more astonishing.

5.3.4 Anthropogenic input

The overrepresentation of adult individuals and high-utility body parts suggests that despite the disturbing factor of post-depositional degradation, the bone samples in most levels reflect the exploitation of animal resources by Mousterian hominids (see also Stiner 2002; Phoca-Cosmetatou 2005). An examination of body part representations of camelids, equids, and bovids shows that in many instances at least, complete carcasses were probably processed in Hummal (Tab.8). Unfortunately, the relatively poor conditions of preservation caused a lack of direct evidence for human impact in the form of cut marks or distinct breakage patterns. The only example of direct hominid association is found in burnt and calcined bones, which account for 7.8% of the complete assemblage. Probably as a function of sample size, burnt items are especially frequent in archaeological complexes 5a and 5b of the western section. Nevertheless, the relatively dense scatter of faunal remains and lithics, together with the evidence of fire in levels 5a3, 5a4, 5b3, 5b5, 5b7 and 5E, indicate prolonged and/or repeated occupations during which meat consumption and processing had a significant influence on the technological organization of Mousterian hominids (chapter 8). Due to the drawback exerted by taphonomy, it is impossible to elucidate the concrete relationships between the production of blanks and tools and their use in respect of hunting prey. While this aspect remains a subject for future analysis, we can nevertheless assume, that the overrepresentation of camels, equids and gazelles reflects a hunting strategy that focused on these large, gregarious animals[9]. The camels in particular seem to have been an easy prey with a high net fat yield; unfortunately, only a little information is available about the behavior of camels, and that information relates to camels that were reintroduced into the wild (e.g. Mengli et al. 2006). It is probably not usable as an analogy to the situation in the Middle and Upper Pleistocene.

Apart from providing water, it is highly likely that the artesian springs of El Kowm favored the presence of perennial shrubs and other nutritional plants and therefore attracted large congregates of steppe ungulates at least on a seasonal basis. In this context, we can assume that the lithic technology of Mousterian hominids was mainly oriented towards the production of gear used in the hunt and processing of these animals (Gilead & Grigson 1984). Future research will address the question of how behavioral patterns can be detected by a combination of archaeozoological data and lithic analysis. In the present state of analysis, a model concerning the Mousterian technological organization can at least be offered (chapter 8).

5.3.5 Human remains

Although we are still largely in the dark as regards the question of who exactly occupied the spring of Hummal during the Middle Palaeolithic, two outstanding discoveries made during the 2004 and 2005 excavations provide us with a first step towards an answer. The sample comprises a human radial diaphyseal section and a medial left upper incisor. The radius, which is 109mm long, was unearthed in level 5b1 during the excavation in trench W1 (Fig.55). Despite its fragmentation, the proportions warrant a tentative alignment with early modern humans (Schmid, personal communication 2005). The medial upper incisor was found in level 5a4 and shows a combination of traits that makes an attribution to the Neanderthal group highly likely, considering the root length and crown morphology (Fig.56). Both human remains are currently being analyzed by P. Schmid of the Anthropological Institute and Museum, University of Zurich, and will be presented in a special publication.

[9] The overrepresentation of large-sized species cannot be explained by taphonomic factors alone. It has been shown that the destruction of the cortical bone surface by micro-organisms is more substantial for large mammals than for smaller species like birds or fish (Nicholson 1996).

6 The techno-typological analysis of the Hummal Mousterian

This chapter presents the results which were gained from the technological and typological analysis of excavated Mousterian assemblages in Hummal. Prior to their presentation, some introductory comments concerning research conditions are necessary. Artifact analysis incorporated all assemblages retrieved from the surface excavations which were carried out between 2002 and 2008 (chapter 3). The configuration and quantity of the lithic samples is given in Table 9. Additionally, the composition of single assemblages and comments on their major techno-typological aspects are given in a catalogue in appendix A. Lithic material with a nonspecific stratigraphical origin, such as many test trench assemblages, was roughly examined without recording the whole range of attributes. Excluded from techno-typological analysis were mixed assemblages which were found in colluviated deposits; this concerns assemblage 5h and the lithic samples (alpha-m) retrieved from quartz sand deposits in the center of the well; exceptions were made for assemblages 5a1 and 5d which were excavated in disturbed layers with distinct hints at contamination. Methodological issues and the configuration of applied attribute lists are given in Figure 57 and Tables 10, 11, 12 and 13.

An analytical problem for the study of technological variability within and between the Hummal assemblages is the low sample size in many layers (Tab.9). Excluding small debris, the counts range from two items for levels 5DII and 5DIV to over 600 artifacts for levels 5a1 and 5a3. The use of multivariate statistics is complicated by the problem that many levels delivered an insufficient number of artifacts. Another problem is the impossibility to determine certain attributes on an objective basis with adequate measurements[10]. The limited infrastructure in El Kowm and the time constraints posed for artifact analysis due to the restrictions placed on the exportation of artifact samples for a more thorough examination are the reason for this methodological shortcoming[11]. As a consequence, many technological and

[10] It is theoretically possible to quantify most if not all variables in a lithic study. Yet this requires a significant increase in measurements which, in the end, would render a time-limited analysis not feasible. To give an example, the horizontal inclination of negatives visible on the dorsal surface of a flake was not measured by recording the angle in relation to the flake's flaking axis, although these measurements would allow for a better assessment of the striking platform's extension on the core; the latter aspect would reveal valuable information concerning the mode of recurrent Levallois point production by checking for the amount of core perimeter consumption.

[11] Artifact analysis had to be conducted parallel to the daily field work in the site within one to two months and was therefore reduced to a few weeks per year; two extra-missions for the purpose of data recording were conducted in 2005 and 2007, each lasting one month.

typological features can only be handled as qualitative variables recorded on a more or less subjective basis. Keeping these limitations in mind, it is important to note that many of the forthcoming results and interpretations are preliminary. As long as the research in Hummal is constantly progressing, it is necessary to pursue a systematic evaluation of the data and models which are presented in this study.

6.1 Identifying different reduction techniques

The Levallois concept was the dominant strategy of core reduction in the Hummal Mousterian. Variation in Levallois methods is related to the kind of desired end-product and to the stage of reduction. Variability of core exploitation methods especially occurred during the last production stage which saw a rather opportunistic flake production next to Levallois methods. Prior to this moment in the reduction continuum, the Levallois technique was constantly applied. However, it has to be reckoned that alternative flaking techniques played a role, yet to a lesser degree. Their recognition is faced with the problem of visibility or sample size. For example, evidence is given for the production of Kombewa and Janus flakes, the production of which was done on the ventral face of huge flakes (chapter 6.8). Because Kombewa flakes are the first products obtained, they are easily recognizable due to their unique double ventral surface configuration. However, with ongoing reduction a large range of possibilities for secondary flake exploitation is given, in which the parent flake can be reduced on one or two sides and at different sections, for example. In some cases, core on flakes were used for the production of Levallois blanks. The difficulty in reconstructing core reduction techniques increases with the degree of exploitation visible on waste cores. As the latter are found totally reduced in Hummal, they are only partly indicative of antecedent flaking techniques. Sample size is an inherent problem of the technological interpretation of flakes produced from limestone pebbles. Their morphology suggests that the removal of blanks did not follow the Levallois concept. Nevertheless, due to the lack of limestone cores, it can only be assumed that the flaking technique resembled a discoid or Levallois-like strategy.

In the present state of analysis, five different flaking methods are identifiable in the Mousterian assemblages of Hummal (see also Fig.58):

1. The <u>Levallois technique</u>: it was applied either throughout the core reduction sequence including flint and maybe limestone as well, or just during the early phase of blank production.

2. The opportunistic method: many waste cores exhibit traces of an unstructured removal of blanks prior to their discard.
3. The secondary reduction of flakes: complete or broken flakes were systematically recycled by using variable methods of blank production
4. An informal flaking method applied to limestone pebbles: the technological status of this method is unresolved due to the small sample size of limestone artifacts.
5. The non-Levallois blade production on prismatic cores: evidence for this method is scanty. It is proven by three small waste cores and a few non-Levallois blades and seemed to have been applied during the final core reduction stage.

These different flaking methods were of varying importance. The informal reduction of limestone pebbles and the non-Levallois blade production on prismatic cores are "exceptions to the rule" in the sense that these methods did not play a significant role for tool supply. If future research on the basis of larger artifact samples will not prove the contrary, both flaking methods are definitely incidental and it is even possible that corresponding artifacts were accidentally derived.

Attributing each single flake or core to a certain reduction technique is a challenge. Apart from unequivocal Levallois products and Levallois cores which display typical features of this technique, identification of blanks that were derived from an opportunistic exploitation strategy at the end of the cores' use-life is extremely difficult. Cores on flakes only present a slight identification problem since most of them are recognizable, though perhaps not immediately in cases of marginal flake reduction. Core trimming elements are more or less classifiable according to their function, but attributing them to different techniques faces the same problem. This analytical difficulty results from two reasons. First, the nearly exclusive focus on one single flint variety resulted in similar reoccurring technical steps and decisions which are related to specific properties of this raw material variety and generates the impression of a technological homogeneity. In other words, not only the Levallois method was executed on Eocene flint, but also alternative technological strategies. Second, because the main part of flint mass was reduced by the Levallois method, whereas other techniques were applied to exhausted raw material units, identification of the latter is hampered by small sample sizes and similarity of items in terms of shape. For instance, it is impossible to differentiate between flakes which stem from the preparation of the flaking surface on a Levallois core from small blanks that were struck from an exhausted core in an arbitrary fashion. The same holds true for the main part of blanks produced on cores on flakes.

In the following section, the different core reduction techniques will be described by presenting relevant artifact categories and their technological attributes. A crucial problem in lithic analysis is the clear-cut definition of technological and typological categories. While a retouch bearing flake can unambiguously be classified as a tool or a nodule showing flake removals as a core, the classification problem relates to the distinction between intended flakes and by-products of a reduction sequence. The question of where to draw a line between both categories is especially eminent in studies which lack refitting possibilities (e.g. Hovers 2009; Van Peer 1992). In Levallois blank bearing assemblages the question is often expressed as the difficulty to distinguish between "Levallois" and "non-Levallois" flakes (Copeland 1983a; Hovers 2009). Attempts to separate both categories on the basis of an attribute analysis did not result in workable definitions (e.g. Dibble 1989; Perpère 1986). Copeland (1983a) and Goren-Inbar (1990) proposed to use an "indeterminate" category: however, as the term already implies, objective criteria are lacking. In her detailed study of the Mousterian assemblages of Qafzeh Cave, Hovers (2009) designates "core trimming elements" (CTE) only those artifacts which show distinctive traits, such as cortical flakes, backed knives, plunging core edge elements and pseudo-Levallois flakes. Except for identifiable Levallois and Kombewa blanks, remaining flakes are considered as "non-Levallois" blanks and not as "core trimming elements" although it is admitted that they probably result from preparatory processes within a Levallois flaking sequence (Hovers 2009, 104).[12] The result is a high proportion of blanks compared to CTEs in all Qafzeh levels (Hovers 2009, Fig. 7.1). In the present study, these core management flakes are not referred to as blanks as will be explained in chapter 6.6.7.

6.2 The Levallois method of core reduction

The Levallois method was the preferred mode of core reduction in the Hummal Mousterian. The focus on a single concept generates a homogeneous picture of technological gestures across the Mousterian sequence and probably mirrors several different aspects:

- homogeneity of raw material: except for a few limestone pebbles only high-quality flint was used.

[12] The assumption that "Levallois" and "non-Levallois" blanks are technologically interconnected is based on the fact that both categories reveal similar platform angles and scar pattern frequencies. The claim that "non-Levallois" flakes can be interpreted as blanks because use-wear studies proved their use (Hovers 2009, 104) does not solve the classification dilemma. Many "typical" CTEs, such as backed knives, equally display use wear or were modified into retouched tools (e.g. Lemorini et al. 2006; Rios et al. 2008).

- technological tradition: it is possible that the exclusive use of the Levallois technique corresponded to a cultural norm
- efficiency and reliability: the recurrent production of Levallois blanks allows for a rapid removal of morphologically predetermined flakes; this aspect is clearly expressed by the majority of Levallois points showing a high degree of morphological standardization.
- flexibility: the production of Levallois points on both cores on flakes and nodule cores shows that the Levallois concept can be applied to variable shapes of raw material units.

Cultural norms which guided the way of blank production and tool shaping are certainly to be seen as a factor standing behind the general “technological monotony” in the Hummal Mousterian. While a stable tradition in terms of focusing on the Levallois method influenced artifact production during all Mousterian occupations at Hummal, variability is visible in the kind of Levallois methods applied. We can observe changes in the size, morphology and frequency of Levallois blank types between levels (chapter 6.12.2).

The efficiency and reliability of the Levallois technique is difficult to prove and standardization of end-products is largely a subjective impression left by the material under observation. Brantingham and Kuhn (2001) showed that Levallois core efficiency can be high compared to other core forms in terms of waste material lost and number of blanks produced, provided that a basic parameter, namely a steep platform angle, is constantly given. Experimental studies which tested the long held belief that Upper Paleolithic blade production is more efficient than a Middle Paleolithic flaking method showed that flake production on Mousterian-type discoid cores is equally efficient in terms of cutting edge obtained per gram of flint than serial blade production (Eren et al. 2008). This aspect is presumably even more pronounced in the case of the Hummal Mousterian. The El Kowm flint’s excellent quality allowed for a recurrent removal of thin, elongated Levallois blanks coupled with a minimal need for surface preparation on the cores. Moreover, the optimal fracture properties of this flint variety guaranteed an unblocked propagation of the blow, and hence, end-products with feathered terminations are obtainable. Standardization can to a certain degree be assessed by examining the variability in shape and size of Levallois blanks, as will be done in chapter 6.5.

6.2.1 Theoretical aspects of the “Levallois phenomenon”

The question concerning the actual nature and terminological definition of ”Levallois“ in terms of a knapping method and the attributes of resulting products is a matter of ongoing debate (e.g. Boëda 1994, 1995; Bordes 1980; Chazan 1997; Copeland 1983a; Dibble & Bar-Yosef 1995; Eren & Bradley 2009; Hovers 2009; Perpère 1986; Sandgathe 2004; Van Peer 1992). Based on knapping experiments and archaeological data, Geneste (1985) describes succeeding stages of the Levallois core reduction sequence and offers a catalogue of related by-products. Equally relying largely on an experimental approach, Boëda (1982, 1990, 1994, 1995) proposed a redefinition of the Levallois technique which centers on a geometric conception of the core and is basically an extension of Borde's original Levallois definition. He defined five basic and interrelated parameters that characterize the Levallois technique and distinguishes it from other flaking methods:

1. The core is composed of two intersecting planes, the striking surface and the flaking surface
2. These two surfaces are hierarchically organized and do not change their role during the reduction process
3. The flaking surface is prepared in such a way that blanks with a predetermined form can be obtained.
4. The fracture plane is sub-parallel to the plane of intersection
5. The striking platform is carefully prepared to allow a controlled removal of blanks parallel to the intersection plane.

Although accepting the basic validity of Boëda's definition, many researchers stress the variability of Levallois signatures in the archaeological record and argue for an enlarged conception of the Levallois technique (e.g. Dibble & Bar Yosef 1995 and references therein; Guette 2002, Sandgathe 2004). Contrarily, researchers which are confronted with static archaeological assemblages argue that for the sake of classification the Levallois concept definition is too vague and lacks tangible attributes for the recognition of end-products (Copeland 1983a; Hovers 2009). Others stress methodological shortcomings by arguing that a diacritical reading of artifacts delivers unreliable results due to technological congenialities and variability of possible gestures (Bar-Yosef & Van Peer 2009; Van Peer 1995) or by pointing to the lack of quantifiable classification systems (Dibble 1989; Gilead 1995).

In the present study, qualitative and quantitative attributes are used to describe the mode of Levallois core reduction (Tab.10, Tab.11, Tab.12 and Tab.13). The Mousterian levels of Hummal reveal variable Levallois core reduction methods in connection with changing production aims which result in differing proportions of flakes, blades and points. Inter-assemblage variability is largely seen as an expression of technological traditions and changing site-use patterns. In the remainder of this chapter, the general aspects of the Levallois reduction technique as it was applied in Hummal and its basic *chaîne opératoire* will be described. Several questions are of interest here:

- Which Levallois methods were applied?
- What do corresponding Levallois blank types look like and can they be differentiated in terms of size and morphology, and if so, in which scale?
- In which way were the striking and flaking surfaces of Levallois cores maintained?
- At which threshold in the reduction sequence was the Levallois method no longer applied?

6.3 Levallois reduction strategies in the Hummal Mousterian

Attribute analysis of Levallois blanks and waste cores shows that two different flaking methods were applied:

1. the lineal Levallois method
2. the recurrent Levallois method

Both Levallois reduction strategies were identified and described by Boëda (1994, 1995; Boëda & Pélegrin 1979) and Van Peer (1992). The basic difference between both methods is related to the investment of core preparation, rate of blank yield, and blank morphology. Cores which exhibit the removal of one central Levallois flake are normally considered as remains from the lineal method for blank production. The flaking surface is centripetally prepared with the help of small removals before a single, preferential Levallois flake is struck from the core. After each blank removal, the flaking surface has to be prepared again to restore necessary convexities. Depending on the arrangement of scars and core size, all kinds of blanks can theoretically be obtained, but rectangular or oval-shaped flakes are frequently mentioned as typical end-products. The substantial effort of preparation causes a relatively rapid loss of core volume, and hence, the lineal method yields a lower rate of blanks compared to the recurrent Levallois method. A variety of the lineal Levallois method is the production of "classical" Levallois points on specially prepared cores. The flaking surface preparation is done with converging removals struck along both core edges from a single striking platform. The converging scar pattern allows the removal of a pointed, triangular

Levallois blank for which the blow was set on a carefully prepared part on the striking surface to gain better control during flaking.

The recurrent Levallois method is an efficient mode of core reduction in the sense that more than one blank is obtained before each moment of core preparation. Each blank series is comprised of flakes which are predetermined and predetermining at the same time. They are predetermined by the way the flaking surface is shaped, and they are predetermining, as each blank removal leaves a distinct scar pattern on the core's surface which serves as a guide for the subsequent flake removal. Several varieties of the recurrent method depending on the core morphology as well as location and extension of the striking platform were proven by experiments and archaeological data (Boëda 1994, 1995; Van Peer 1992). To mention is the unidirectional, bidirectional and centripetal flaking method.

Both Levallois methods with several varieties of each were identified in the Mousterian assemblages of Hummal. While some methods, such as the recurrent production of flakes and blades, can be found throughout the sequence, others are restricted to certain levels. Altogether, 1058 Levallois blanks, 354 Levallois fragments and 34 Levallois cores were amenable to a detailed technological analysis[13]. The total stock of the debitage assemblage (excluding fragments) comprises 40% Levallois flakes, 35% Levallois blades and 25% Levallois points. Tables 14 and 15 show the number of blanks and cores which were collected in each level. The predominance of Levallois blanks is mirrored by high Levallois indices (IL) which never fall below 80.

Attribute analysis of Levallois blanks and cores shows that the Hummal Mousterian can be characterized by two general tendencies:

1. In all levels, elongated blanks were desired end-products
2. In the majority of levels, the unidirectional convergent method was used to obtain Levallois points and triangular flakes.

The frequency of elongated blanks is certainly to be correlated with the presence of high-quality raw material in the form of voluminous blocks which can be found at primary outcrops in the El Kowm region. This favorable raw material situation allowed for the preparation of huge cores and no constraints were posed on core morphology. It is also possible that the predominance of laminar blanks mirrors a stable technological tradition;

[13] Analysis of general technological trends was done with all assemblages derived from surface excavation (chapter 5.1 and chapter 5.2) as well as material from test pits and profile cuts for which at least a broad stratigraphic reference is given. Material which did not fulfil these requirements, such as the alpha-m assemblages, was not included.

however this assumption is difficult to prove. Whether an increasing elongation of blanks can be seen as a further benefit in terms of utility and transportability beyond the economic benefits gained already by the Levallois method is doubtful. The systematic presence of laminar blanks in the Mousterian assemblages of Hummal is better seen as an answer to functional requirements within a steppe environment. The factors on which this assumption are based are discussed in chapter 8.

The predominance of triangular flakes and Levallois points which were produced by the unidirectional convergent method correlates a large part of the Hummal Mousterian sequence with other point-dominated Levantine assemblages showing similar features. It has been shown that the production of Levallois points and subtriangular flakes with the help of this technique is a main characteristic of the Levantine Mousterian (Bar-Yosef & Meignen 1992; Meignen 1995). Its basic technological parameters can be reconstructed by the morphology of Levallois points, Levallois point cores and typical by-products, such as backed knives, core edge flakes, and twisted plunging blades or overshot flakes.

6.4 Levallois core reduction aims in Hummal

Reconstructing the aims of core reduction in each Mousterian level can be done by examining the respective frequency of Levallois blank categories, namely flakes, blades and points, as well as the Levallois core types. Classifying each flake according to these blank categories requires the analysis of certain attributes, such as flake shape, elongation, symmetry, and dorsal scar pattern. Flakes with a pointed distal tip, triangular morphology and convergent scar pattern were designated as Levallois points. Sub-triangular flakes posed a taxonomic problem and where allocated either to the point or to the flake/blade group according to their scar pattern. A LWR of 2.0 was set as a limit between flakes and blades for non-triangular blanks. Application of this classification system delivered the following results (Tab.14): In the upper two third of the Mousterian sequence from level 5AII to 5E, points account for 20% to 40% of all Levallois blanks in artifact rich assemblages. Contrarily, at the bottom of the Mousterian sequence, in levels 5f1 to 5g, points are rare and their percentage among Levallois blanks is found below 10%. These levels are clearly dominated by Levallois flakes and blades. The preponderance of Levallois flakes and blades in all point-bearing levels has to be interpreted with caution, as a considerable number of flakes and blades can be seen as by-products of Levallois point production.

The number of Levallois cores is surprisingly small, and many levels lack any such core type (Tab.15). As a consequence, the Levallois core to blank ratios are extremely low, ranging from a minimum 0.01 in levels 5AIV and 5E to a maximum of 0.18 in level 5AV. The scarcity of Levallois types in the core group can be explained by the fact that many of them underwent an opportunistic exploitation before discard and therefore ended as non-Levallois flake cores (chapter 6.7). Other factors, such as the export of cores to other localities, could have equally played a certain role.

The Levallois cores can be classified according to the type of blank which was the last removed as well as the method with which they were exploited (Tab.16). Half of the 28 Levallois cores are point cores, whereas flakes and blades were removed from the other half. The majority exhibit traces of a recurrent blank production and the negative of a last preferential blank was visible on only six items.

6.4.1 Blank shape and the "triangular flake" problem

Table 17 shows that over 90% of points, not surprisingly, exhibit a triangular shape, whereas the flake/blade group is dominated by polygonal or quadrangular shaped pieces. Rounded and markedly thick, conical types are rare. This is due to the fact that the Levallois method works with sub-parallel flaking planes relative to the intersection of both core surfaces. The taxonomic problem regarding triangular flakes and blades is significant as around 30% of these blank types are of this shape. Are these blank forms atypical Levallois points or just triangular blanks? The fact that a substantial grading exists between both groups and analytical criteria are not sufficient for an objective differentiation, allocation to either group is done largely on subjective grounds.

Other researchers faced the same problem when dealing with point-dominated Levantine assemblages (Meignen & Bar-Yosef 1991; Meignen, personal communication 2004). Given that many published inventories lack a detailed description of applied classification criteria, this problem seriously affects inter-site comparisons.

In the present study, every triangular flake was checked for its symmetry and dorsal scar pattern. Flakes which do not exhibit a distinct triangular shape, symmetry and/or convergent scar pattern were generally considered "triangular" Levallois flakes or blades. Many of these pieces received this form by accident. Asymmetrical or twisted triangular flakes which exhibit a unidirectional convergent scar pattern can be classified as "atypical" Levallois points and were found in every Levallois point-bearing assemblage. Their frequency is shown in Table 18. In Levallois point assemblages, triangular flakes account for between 10% to 25% of all Levallois blanks and are probably to be seen as atypical end-products of a recurrent Levallois point production (Meignen 1995). In fact, the purpose of setting a limit between true points and triangular flakes is largely a typological problem and its relevance for the reconstruction of past behavior is doubtful. Differing classifications however can be a problem when we wish to estimate the actual degree of Levallois point vs. Levallois flake and blade production. As a rather conservative definition of Levallois points bears the risk of underestimating the actual amount of Levallois point manufacture, the frequency of convergent scar patterns in a given level is seen as a more reliable indicator of the degree of point production than blank shape.

6.4.2 The dorsal scar pattern of Levallois blanks and cores

Regarding point-bearing assemblages, the preference for the unidirectional convergent flaking method to obtain Levallois points is evidenced by the fact that in all levels over 85% of all items exhibit a corresponding scar pattern. It is also visible on 11 identifiable Levallois point cores (Fig.59, Nr.3-5). A variation of the unidirectional convergent flaking method is the perpendicular preparation of the flaking surface. Resulting Levallois points exhibit two converging removals struck from the basal striking platform and another perpendicular removal struck from the left or right core edge (e.g. Fig.135, Nr.3; Fig.146, Nr.5). Specimens with bidirectional scar patterns evidence the production of Levallois points with the help of two opposed platforms (Fig.145, Nr.4). However, both the perpendicular as well as bidirectional flaking technique were rarely applied and account for only 5% of dorsal scar patterns observed. The predominance of the unidirectional convergent method of Levallois point production technique presumably demonstrates the efficiency of this flaking technique to obtain standardized triangular blanks as well as the influence of technical norms.

The frequency distribution of scar patterns recorded on Levallois flakes and blades is given in Table 19 and Figure 60. It can be seen that assemblages with more than three items in complexes 5A to 5E comprise between 7% and 67% Levallois flakes and blades which show a convergent scar pattern. These pieces are definitely outcomes of point production series. In point-bearing assemblages, non-triangular flakes with a convergent scar pattern are either preparative removals, which were struck with the intention to re-shape the flaking surface for further point removals, or alternative end-products obtained within a point-production sequence. It is fairly possible that in the process of Levallois point production other blank types were equally desired end-products for which a major reshaping of the core seemed unnecessary. The frequency of these blanks quantitatively demonstrates the failure to correctly assess the importance of Levallois point production on the basis of point frequency alone. The difference between the percentage of Levallois points and the percentage of these points combined with blanks showing a convergent scar pattern is shown in Table 20. The inclusion of blanks prepared in a convergent pattern does not mean that all these pieces are seen as possible points but that their dorsal scar pattern relates them to Levallois point production sequences. As can be seen in Table 20, the difference is considerable in many layers. This implies that the degree of point production would be severely underestimated in case the estimation is based on Levallois points alone. In the majority of levels with N>5, points comprise between one third to around a half of all Levallois blanks. Yet, with the inclusion of flakes with convergent scar patterns, it can be seen that in many levels, the reduction of Levallois point cores generated around a half or more of all Levallois blanks; this is even the case in some levels which lack Levallois points, probably because of small sample size. Furthermore, column 4 in Table 20 shows an increase in the significance of point production with level 5AVI onwards, which is curiously not expressed by rising point frequencies. Again, sample size may be the determining factor.

Despite these interpretative problems concerning some Levallois flakes and blades, a significant number can be seen as deliberate blank forms which were produced by alternative Levallois methods. No difference in scar pattern frequencies exists between flakes and blades, suggesting that the difference between both blank types is a matter of elongation and not technology. Hence, both blank types can be grouped together. The frequency distribution of scar patterns for Levallois flakes and blades shows that the unidirectional-parallel flaking method was regularly applied (Tab.19 and Fig.60). In 10 out of 17 representative assemblages, this flaking method was the most important way to obtain polygonal or rectangular shaped Levallois blanks (Fig.61). In the middle part of the Mousterian sequence, in levels 5a2 to 5E, artifacts showing a unidirectional parallel scar pattern account for more than 50% of all flakes and blades. In the uppermost, point-dominated assemblages of Hummal, in levels 5AI to 5AVI, the unidirectional-convergent method was the most important flaking strategy, not only for the points but also for flakes and blades. In all levels except for the lowermost ones, the use of a flaking surface with perpendicularly arranged scars is attested by some of the flakes and suggests a lateral extension of the striking platform. A marked diversity of flaking methods is visible in the lower Mousterian sequence, in levels 5e to 5g. Although sample sizes are small in each of these levels, it seems evident that during the earliest Mousterian occupations, a variety of blank types were produced with different methods. As Levallois points are rare in these assemblages, it is not surprising that the unidirectional convergent method was of no importance. Levallois flakes and blades were frequently struck from (semi)centripetally prepared cores as preferential blanks or produced with the recurrent centripetal method. The frequency of blanks which exhibit a bidirectional scar pattern suggests that some cores were recurrently exploited from two opposed striking platforms.

6.4.3 What about blades in point-dominated assemblages?

The problematic distinction between end and by-products in Levallois point-dominated assemblages is especially given for Levallois blades because refitting studies have demonstrated that many of them are derived by the shaping of the point cores' flaking surface (Demidenko & Usik 1995; 2003). This observation seems corroborated by the high numbers of blades in point dominated industries (D.O. Henry, personal communication 2008). In the majority of Hummal assemblages, Levallois blades account for 30% to 40% of all Levallois blanks (Tab.14). Without the help of refittings, it is impossible to draw a clear line between by-products and true Levallois blades. Nevertheless, it has been observed that the preparative blades which create the inverted Y-scar pattern on Levallois point cores are frequently twisted in their longitudinal axis and/or overshot (Demidenko & Usik 1995; 2003; Meignen 1995). If such pieces are struck alongside the core edge and removed a significant part of the latter, they can be easily classified as core edge flakes (*débordant* flakes) within the group of CTEs (chapter 6.6.5). Core edge flakes account for 10% to 30% of all CTEs in point-bearing levels. The majority exhibits a marked curvature or twist in their longitudinal section. This is a common feature of preparation flakes stemming from Levallois point cores. They are accompanied by many trimming flakes with a convergent or perpendicular scar pattern which comprise on average 30% of all CTEs. Point core trimming blades which lack core edge remains are hardly distinguishable from true Levallois blades except for a twist in their longitudinal axis. This attribute has been observed on 30% of all Levallois blades, and hence, it has to be assumed that in point-dominated assemblages, at least one third of Levallois blades are potential by-products. Overshot Levallois blanks are extremely rare and account for no more than 1% of all blanks.

6.4.4 The quantity of cortex on blanks and cores

In all levels, around 90% or more of all Levallois blanks exhibit either no or only a small amount of cortex cover (10%-20%) on their dorsal surface (Tab.21). The fact that cortex-bearing blanks are found within the upper size range shows that they were produced during the early stage of core reduction when the flaking surface was not completely freed from cortical patches. The scarcity of flakes with more than 20% cortex cover indicates that decortication always preceded Levallois production. The transitional zone between the outer chalky surface and inner flint core, which is already exploitable, can in some cases be considerably thick. The blanks with a substantial amount of cortex on their dorsal surface (>50%) were always produced within this zone. The Levallois point cores exhibit a substantial cortex cover (50 to

90%) on their lower surface, and it can be assumed that round flint nodules or voluminous cortical flakes were preferentially collected for point production. Preparation of the lower surface and the creation of secondary striking platforms occurred more frequently on Levallois flake cores. Consequently, the majority of these core types exhibits less than 50% cortex and a higher number of negatives on the lower side compared to Levallois point cores**.**

6.4.5 The size of Levallois blanks and cores

An inter-assemblage comparison of blank size is hampered by the small sample size in many layers. The results frequently lack statistical significance, but nevertheless deliver preliminary hints at technological variability as well as differing patterns of raw material provisioning (see also chapter 8). The mean size of exhausted Levallois point cores, which is given in Table 16, shows that the volume threshold for the production of points is a size of around 6 x 6 cm and a thickness of around 2cm. This suggests that points in the range between three and five centimeters were the last removals.

The mean size of Levallois points is given in Table 18 and Figure 62. Limiting the analysis to point-rich assemblages (N>10), it can be seen that the uppermost levels 5AII and 5IV are dominated by relatively large and thick points with an average size of 7.5 x 3.5 cm. In the middle part of the sequence, many points are of similar size. However, some assemblages, such as level 5a2, 5b3 and 5b5 contain a significant proportion of smaller specimens. The presence of small points with a surface size of 15cm^2 or below matches the size threshold which has been observed for abandoned point cores. The variability in surface size observed among large points of different assemblages may be due to unequal raw material volumes which were at hand. On the other hand, the absence of small Levallois points in the range below 20cm^2 in archaeological complex 5A and the presence of such points in underlying levels is probably a result of differing technological parameters used in the recurrent production of these blank types. In Figure 63 complex 5A and a group comprising levels 5a2 to 5E are compared with respect to the median, 25th, 10th and 5th percentile of surface size. It can be seen that the percentiles of complex 5A systematically correspond to larger size values than it is the case for assemblage group 5a2 to 5E. This suggests that the flaking method which produced the points in levels 5a2 to 5E allowed for a more extended reduction of cores than was the case in the uppermost Mousterian levels.

The inter-assemblage variability of Levallois point size is paralleled by a similar pattern observed for flakes and blades across the sequence (Tab.22 and Fig.20). Despite the small sample size issue, inter-assemblage variability is significant. Complex 5A displays a relatively homogeneous size distribution, whereas the following sequence between levels 5a2 and 5E shows a more variable pattern. The average size of flakes and blades is not only fluctuating between, but also within single levels. Complex 5a as well as levels 5b5 and 5b7 contain a significant number of small flakes, whereas they are scarce in levels 5b2, 5BII, 5b3. It seems that a general decrease in flake size occurs from level 5a3 to level 5b7 which is also matched by a decreasing size of Levallois points in these levels; level 5b7 is an exception with large-sized points occurring next to small-sized flakes and blades. As for the points, the smallest flakes and blades were found in level 5b5 with a mean size of 5.2 x 2.7 cm (Tab.17 and Tab.22). It is interesting to note that their smaller size compared to other levels is not coupled with a lower thickness, suggesting that the size difference is rather caused by a difference in the shape of raw material blocks than technology. In the middle part of the sequence, a comparison of Levallois blanks between adjacent levels 5a2 and 5a3 reveals that the former are on average considerably smaller than the latter, especially the flakes ($t = -2.23$; $p = 0.03$; Tab.22). Further, in some layers the median length values are considerably lower than the mean values, which commonly fall into the range of 5 to 7cm.

The abandoned Levallois flake and blade cores exhibit an average dimension between 5 and 6cm and a remaining thickness of slightly more than 2cm (Tab.16). Flakes and blades of the lower size range in assemblages 5a2 to 5E are the likely candidates of end-products which were removed from these waste cores. As has already been seen for the points, small blanks with a size below 4cm are lacking in the uppermost Mousterian levels. By far the largest Levallois flakes and blades are found in the lowermost part of the sequence, in levels 5e to 5g. Again, the absence of small blanks is noticeable in these levels.

The homogeneity between Levallois flakes and blades in levels 5AI to 5E, which was already noticed with the scar pattern frequencies, is corroborated by a strong similarity in surface size. A comparison of mean values shows that no significant discrepancy exists between both groups ($p = 0.541$; $T = -0.612$). Likely, no size difference exists between the grouped flake-blade sample and Levallois points ($p = 0.339$; $T = 0.957$). In some levels, points are slightly larger with a difference between 1 and 5mm. This could be an indication that the production of points was frequently stopped at an earlier moment in the reduction sequence than the production of flakes and blades. However, in general, all Levallois blank types were produced throughout the whole reduction sequence. The homogeneity in size of flakes and blades further corroborates the assumption that in the upper two third of the Mousterian sequence the main purpose of core reduction was to supply elongated flakes and blades with the help of the recurrent unidirectional-parallel method; the scarcity of short, squat flakes suggests the low importance of other blanks forms. The LWR determined for Levallois flakes, blades and points reflects this laminar tendency (Tab.17 and Tab.22). An inter-assemblage comparison shows that the mean LWR values cluster between 1.7 and 2.8. In 17 out of 26 analyzed levels, the mean LWR is found at 2.0 or even higher; the strongest laminarity of blanks is found at the base of the middle sequence in levels 5b7, 5DV and 5E. Despite a more variable spectrum of applied flaking methods, the mean LWR of the lowermost Mousterian assemblages is identical to the overlying samples. The homology regarding blank elongation independent of the technological context is thus a common feature of the Hummal Mousterian.

Although the majority of Levallois blanks in all levels were struck from elongated flaking surfaces, their production was accompanied by a differential volume loss on the cores. The quantitative assessment of this variability in volume consumption can be measured by the index of relative thickness (RT) which was defined by Weber (1991) and which is calculated as:

$$RT = \frac{T}{0.5 * (L + W)}$$

where T is the thickness measured at the artifact's midpoint and L and W are the artifact's length and width respectively. The RT sets the thickness of an artifact in relation to the average of length and width. An inter-assemblage comparison of mean LWR and RT values shows that in some assemblages the elongation of Levallois blanks is coupled with a high volume whereas in other levels a contrary relationship is observable. The respective pattern is similar for Levallois points and the flake-blade group (Fig.65 and Fig.66). Levels 5AII and 5a4 can be characterized by a raw material intensive production in the sense that the blanks' elongation was achieved by a higher removal of flint mass compared to other levels; level 5b2 shows a similar relationship for Levallois points but not for its flakes and blades. Levels 5a2 and 5f1 are the only cases in which relatively thick and squat blanks are responsible for a significant divergence between RT and LWR values. Extremely thin and elongated end-products are found in levels 5b7 and 5E at the transition between the middle to lower Mousterian sequence. The markedly low RT values suggest that they were produced on flat flaking surfaces in combination with a unidirectional-parallel blade production in contrast to the thicker blanks in levels 5AII and 5a4 which were struck from cores with more steeply inclined surfaces. Levallois blank production in levels 5AIV, 5a2, 5a3, 5b3 and 5b5 probably occurred on relatively broad flaking surfaces on which a lower number of blanks with a LWR above 2.0 were removed compared to other levels. Blank elongation in Mousterian level 5f2 is coupled with a significant increase in relative thickness, whereas the opposite trend is discernable in level 5g. The variable patterning of LWR and RT values across the sequence suggests that depending on the morphology of cores, the convexity of the flaking surface was differently arranged. The spectrum ranges from oblong cores with strongly bent surfaces which allowed for the production of elongated blanks with marked central ridges to broad cores with different degrees of surface convexity. The limited sample size in many levels prohibits a comprehensive reconstruction of different core reduction stages, but it seems that the geometry of the flaking surface steadily changed throughout the production process. The rate of flint mass consumption per blank can also be measured by the correlation of the surface size with the RT values. Examining this relationship for flakes and blades shows that inter-assemblage differences exist, which are the possible results of variable morphometric constructions of Levallois cores (Fig.67). In most assemblages, the desired extension of removals on the flaking surface was coupled with a minimal volume loss, expressed by a balance between the mean surface size and RT value. In case the limited size or inadequate geometrical conception of the flaking surface hampered an optimal blow extension, this equilibrium was not attained as can be seen by flakes in levels 5a2 and 5b5 which are relatively thick in relation to their surface size. Level 5b7 again reflects an optimal balance between the length of cutting edge obtained and volume loss on the core. Levels 5f1 and 5f2 contain large-sized blanks which are also relatively thick. This implies that the exploitation of a very convex flaking surface was the only means of generating large-sized blanks.

6.4.6 Maintenance of the striking platform

The majority of Levallois blanks were struck from a restricted, carefully faceted striking platform. The importance of platform faceting to gain better control over blank removal is reflected by high faceting indices (IF) among Levallois points and the flake-blade group (Tab.23 and Tab.24). The similar proportion of faceted butts in the Levallois point and flake-blade group is not surprising as in many levels both artifact categories were produced on the same striking platform. Summarily or unprepared striking platforms were but only rarely used which is reflected by the very low proportions of dihedral and plain butt types in artifact-rich assemblages (2% and 4% respectively). Roughly prepared or plain butt surfaces are systematically linked to blanks which were produced during the early phase of core reduction, as around 75% of the Levallois flakes with these butt types are longer than 5cm. Cortical butts are virtually absent.

Examination of the butt size shows that the production of Levallois points in the upper Mousterian levels 5AII and 5AIV on average consumed a higher mass of the striking platform compared to underlying levels (Tab.23); exceptions are levels 5b2 and 5BII which equally display this characteristic, however, a clear relation between large-sized butts and *chapeau de gendarme* shape is only given in assemblage 5AII and 5AIV. If point-rich assemblages are compared across the sequence, the *chapeau de gendarme* frequency decreases from the uppermost to the lowest levels. Therefore, the increasing importance of Levallois point production in the uppermost Mousterian levels seems to correlate with a high effort of platform preparation which is mirrored by the *chapeau de gendarme.* Regarding the flake-blade group, the largest platform remains and highest *chapeau de gendarme* frequency is equally found in assemblages of complex 5A and demonstrates the close technological connection between points, flakes and blades. The use of a protruding section on the striking platform corresponds with a higher mean flaking angle in the youngest assemblages compared to the majority of underlying levels. The artifact rich assemblages from the middle part of the section reveal a rather strong standardization of flaking behavior which is mirrored by a stable mean flaking angle at 104° in complex 5a and around 106° in levels 5b3 and 5b5. As soon as adequate flaking angles were no longer usable on a core, the latter was abandoned or further reduced with a non-Levallois method. While it is clear that adequate platform angles are a necessary requirement for the application of the Levallois method (Brantingham & Kuhn 2001) and are relatively easily maintained during core reduction (Eren & Bradley 2009), the threshold after which a controlled removal of Levallois blanks is no longer possible is difficult to determine. The Levallois waste cores exhibit exterior platform angles (EPA) between 60° and 80°, and it seems that the lower range can be seen as technical limit (Tab.16).

6.5 Identifying Levallois core reduction techniques

Due to the lack of informative refittings and the low number of Levallois cores, the reconstruction of different Levallois flaking methods principally relies on the above mentioned blank attributes as well as other attributes which have not been discussed yet. The small core sample shows that during the final stage of blank production two different flaking strategies were applied, which is the recurrent and lineal method. The lineal point and flake cores exhibit in the negative a relatively large preferential blank on their flaking surface. Prior to the removal of preferential Levallois flakes, the flaking surface was intensively prepared by striking small flakes from around the whole core perimetry (Fig.59, Nr.6-7). The lineal point cores exhibit only three converging removals (Fig.59, Nr. 4-5). The majority of recurrent-type Levallois cores exhibit a parallel arrangement of multiple removals on their flaking surface which were all struck from one facetted striking platform. Some of them seem to have been used as Levallois point cores in earlier reduction stages (Fig.59, Nr.2). Alternative flaking strategies are represented by only three cores showing a perpendicular, bidirectional or centripetal arrangement of removals. The recurrent type of Levallois point cores show traces of several overlapping, unidirectional negatives on their flaking surface. Only one specimen exhibits a perpendicular scar pattern. Recurrent and lineal-type point cores are of equal size and were mostly abandoned due to their remaining volume being too low for further production.

While an identification of recurrent and lineal core types poses no problems, the differentiation between recurrently produced blanks and preferential specimens is an analytical challenge (see also Gilead 1995). During the analysis of the Hummal material, it was not possible to draw a clear line between the end-products of both Levallois methods. However, some feature characteristics seem to be influenced by the two flaking methods, as will be shown below.

6.5.1 Levallois point reduction strategies

About a quarter of all Levallois points are of the "classical" type. These pieces exhibit the typical features of textbook examples: a perfect triangular outline, highest width at the base, *Concorde*-shaped distal termination, Y-type of dorsal scar pattern formed by three overlapping negatives, and a *chapeau de gendarme* type of butt (Fig.68). This attribute combination renders it highly likely that they were produced with the lineal method. The majority of Levallois points were produced with a recurrent method. In most instances, a series of two or three converging points were struck from a single faceted striking platform. Recurrently produced points deviate from the "classical" types in relation to the dorsal scar pattern, outline, volume distribution or butt shape[14]. The specimens are often asymmetrical and slightly twisted in their longitudinal axis and many lack a *chapeau de gendarme* type of butt (Fig.69, Nr.1-4). Another typical feature is the presence of one or more scars which stem from anterior point removals on their dorsal face (see also Meignen 1995 for a technological definition of recurrently produced Levallois points). The creation of a unidirectional-convergent scar pattern on cores was sometimes realized with more than three negatives. These "constructed Levallois points" (Boëda 1982) account for 40% of the sample and exhibit between four and up to seven removals. In the uppermost Mousterian levels 5AI to 5AVI, a special variant of the recurrent Levallois point production is identifiable which corresponds to a high frequency of these >3

[14] The Levallois point sample was not divided into technomorphological groups, which were defined by Boëda (1982; Boëda et al. 1998) on the basis of different scar patterns. Such a classification can be useful if statistically significant patterns of Levallois point core preparation are discernable within or between assemblages. As this is not the case in the Hummal Mousterian with the exception of uni and bidirectionally produced points in the lowest levels, analysis was done without a comprehensive Levallois point typology. Moreover, the variability in Levallois point morphology is seen as a result of situational gestures within dynamic core reduction processes which aimed at obtaining a sharp triangular blank, and it therefore escapes rigid typological systems.

negative points. A significant number of large Levallois points exhibit preparative and two or three anterior triangular-shaped removals in their proximal half. After these removals, a protruding section was prepared on the striking platform before the last point, which covered a substantial part of the flaking surface and shows a *chapeau de gendarme* type of butt, was removed (Fig.69, Nr.5-7). As these last points are of the preferential type, this technique of point production reveals an intrinsic connection between the recurrent and preferential Levallois method (see also Meignen 1995, 367 for similar observations in Kebara units IX-X). It differs from the recurrent mode of point production in the middle part of the Mousterian sequence (levels 5a2 to 5E) in relation to several technological features. First is the obliqueness of the converging removals visible on the dorsal face of Levallois points. The recurrent production of points in the younger Mousterian assemblages resulted in strongly converging negatives with very open angles, which often approach a perpendicular or semi-centripetal pattern. This shows that the first triangular removals were produced from laterally extending striking platforms. The last point removal then occurred in the center of the proximal platform. Points found in underlying levels exhibit more acute angles, and this observation indicates that the distances between the striking points were closer and the overlapping area of points was larger compared to the upper levels. Hence, the degree of convergence is lower and the unidirectional convergent flaking concept frequently approaches a unidirectional parallel one. Next to a difference in the extension of striking platforms, the two technological variants can also be distinguished by differential rates of platform consumption (Tab.23). It has been shown that Levallois points which were found in the uppermost levels reveal larger platform remains than their counterparts in underlying levels. Variability is further given in respect to the mean number of proximal negatives visible on the points (Tab.23). Levallois points in the upper Mousterian assemblages 5AII to 5AV exhibit on average four or five proximal negatives, whereas respective mean numbers are lower in the majority of underlying levels. In fact, some lower Mousterian assemblages do contain points with more than three negatives; however, they are of smaller size compared to the scars visible on the specimens from the uppermost levels. A further discriminating attribute which probably correlates with the differential size of striking platforms is the frequency of *chapeau de gendarme*-shaped butts, which is higher in complex 5A (Tab.23). As preferential Levallois points, which normally carry this special butt type, are found in each assemblage, it is the higher number of recurrently produced pieces with a *chapeau de gendarme* butt which distinguishes levels 5AI to 5AV from underlying assemblages.

The variability in recurrent point production modes can be summarized by two basic variants of the convergent unidirectional Levallois method. In the first case, triangular flakes and points with a relatively broad base and a scar pattern, which shows strongly converging negatives, are typical blank forms. The second mode of point production aimed at rather narrow, elongated points with unidirectional to parallel scar patterns and narrow butts. Both cases have been identified by Meignen (1995) as being two different varieties of the unidirectional convergent flaking method in Levantine Mousterian assemblages. Like in other Mousterian sites, such as Kebara Cave, the recurrent production of Levallois points occurred parallel to the lineal method. The close technological relationship between recurrently and preferentially produced points impedes their separation with the current classification system. Moreover, the recurrent and lineal method are not to be seen as two separate parallel core reduction methods but rather as interconnected flaking strategies as is evidenced by the last, large-sized points produced after a recurrent series in the upper Mousterian levels. As we are not able to single out preferential types, a morphometric analysis, which aims at a clear discrimination between the two recurrent converging methods, is always influenced to a certain degree by the inclusion of preferential points. One possibility to morphometrically differentiate between recurrent and preferential Levallois points as well as between the two variants of the recurrent method is to check for differences in the lateral extension the points had on the core's flaking surface. Although, the size and elongation of a point is correlated with the shape and volume of the core at hand, we can nevertheless assume that a recurrent unidirectional production of laterally overlapping points was faced with the need to hold their width low, especially in the proximal part of the flaking surface. The two varieties of the recurrent method reflect two different options to compensate for this limitation. One possibility is to extend the striking platform to the lateral sides of the core; the other is to produce narrow points with small butts. The lineal method is not faced with this restriction and thus allows for the production of either narrow or broad point types. To identify broad and narrow based Levallois points on a quantitative basis, a combination of two metric variables, namely artifact width and butt length, can help to differentiate between broad based points and elongated, narrow types, which were also called "leaf shaped" flakes by Watanabe (1968). The latter type of points shows a narrow butt and highest width at the midpoint whereas on broad-based specimens the highest width is found at the base, which is the butt length. Both measurements can be correlated within a ratio called "proximal breadth index" (PBI) which is calculated as:

$$PBI = \frac{butt\ length}{width}$$

Points showing their highest width at the base are represented by values over 1.0 whereas narrow specimens correspond with values below 1.0 (Fig.70). The distribution of PBI values in each level is shown in Figure 71 and corresponding measures of central tendency in Table 25.

In 5 out of 10 point-bearing levels, broad based types account for more than 50% of all Levallois points. Levels 5a2, 5a3 and 5b3 are dominated by narrow, "leaf-shaped" specimens. The inter-assemblage variability in point morphology is influenced by varying frequencies of preferential Levallois points as well as the two different varieties of recurrent unidirectional point production. It is not possible to decide which of the two flaking techniques has a stronger influence in respect to the relatively high PBI values in levels 5AII and 5AIV.

Preferential types are certainly responsible for the high values in levels 5b2, 5BII and 5b5. Levels 5a4 and 5E are equally dominated by points with a PBI value above 1.0, however, most of the specimens somewhat approach the "leaf-shaped" types because of their marked elongation. Short, broad-based Levallois points are very rare in the Hummal Mousterian and seem to be limited to levels 5a1, 5AIV and 5AVI (Fig.147, Nr.3, 8).

The two varieties of recurrent Levallois point production are certainly responsible for the patterns which are observed when the size of points and their volume distribution are examined across the sequence. The broad-based points are on average larger and thicker than "leaf-shaped" specimens and despite similar LWRs their reduction was coupled with a higher volume loss on the core compared to the latter. The relatively high ratio of broad-based items in levels 5a4, 5BII and 5b5 is probably caused by a considerable number of preferential points in these assemblages.

Two recurrent and one lineal-type core evidence the use of large proximal flake fragments for the production of Levallois points (Fig.72 and Fig.149, Nr.1). An atypical Levallois point conjoined with a core on flake found in level 5a3. Prior to Levallois point production which occurred in opposite direction to the fragments' flaking axis, the breaking surface was rudimentarily prepared to install appropriate flaking angles in the range of 70° to 80°. One of the two specimens (Fig.72, Nr.2) exhibits small negatives of some additional preparatory removals at the distal end. The recurrent Levallois point production occurred in exactly the same way as on nodule cores except for a limit in productivity posed by the smaller volume of the flake fragments compared to flint nodules. Regarding their size, the three cores on flakes were abandoned at the same stage as the nodule cores (Tab.16). The flaking surface, which was prepared by two plunging core edge blades, allowed for the removal of at least two overlapping points. Two Janus-type Levallois points evidence the use of the ventral surface of large flakes for a unidirectional convergent blank production (Fig.73). Due to the ventral convexity a minimal preparatory effort was needed and the two points show that only two antecedent removals were necessary before the first point was struck from the flake. The larger one of the two points measures 93 x 32mm with a thickness of 7mm. The fact that both points were produced perpendicular to the flaking axis of flakes shows that the latter were of considerable size.

Apart from Hummal, the reuse of flakes for a secondary production of Levallois points has been attested in other Levantine sites (Goren-Inbar 1988; Henry 2003; Hovers 2007, 2009). In the site of Tor Faraj, the production of small points, usually one per flake blank, was carried out on *Nahr-Ibrahim* core-types and represents the final step in the Levallois reduction sequence (Demidenko & Usik 2003). In Hummal, two different flake exploitation strategies are discernable. Large flakes were exclusively produced to serve as Levallois point cores and subsequently reduced in the same manner than nodule cores. Alternatively, like in Tor Faraj, evidence is given for the recycling of suitable flake blanks which allowed for the removal of one or a few more points.

6.5.2 Levallois flake and blade reduction strategies

The use of the recurrent unidirectional parallel method leaves some idiosyncratic features on corresponding artifacts (Tab.26). Of note is the presence of flakes and blades of second or third order which exhibit one or two negatives from earlier blank removals on their dorsal face (e.g Fig.61, Nr.2, 9-10). These pieces were struck directly after the first blank removal in a coherent reduction sequence in which the blanks are both predetermining and predetermined. The differentiation of second or third order blanks is complicated by the fact that many blanks resemble flakes generated by the trimming of the flaking surface. A careful reading of the artifact is crucial for the assessment of its place in a recurrent production sequence. The considerable time constraints faced by the present study allowed for a sequential ordering of only 478 flakes and blades. Nevertheless, this sample can be considered representative and the results show that at least about a half of all blades and over one third of the flakes are second or third order blanks. Another technological feature, which is diagnostic of the recurrent parallel method, is represented by the considerable number of flakes and blades with parallel running edges. This feature results from the use of parallel ridges left by anterior removals. Flakes which were struck from such flaking surfaces frequently received a polygonal or quadrangular shape (Tab.17). Diverging lateral flake edges which can be achieved by a maximum lateral extension of the blow in the distal half of the core are shown by only 12% of the flakes and 8% of the blades. Such pieces are more frequently found in the lower levels, and it can be assumed that this correlates with a higher importance of the lineal method for blank production during the earliest Mousterian occupations because it is this method which aims at a maximum extension of the blank on the flaking surface. Due to the presence of parallel running negatives which extend over the proximal half of the dorsal face the flakes' cross section is mainly trapezoidal in shape. This attribute is especially frequent among flakes whereas at least 30% of all blades exhibit a triangular cross section. A trapezoidal cross section is created when the point of percussion is placed on an area of the striking platform which is located between two central ridges on the flaking surface. The majority of Levallois flakes were struck in this way in contrast to Levallois blades which were preferentially produced using a central ridge for the blow's guidance. The frequency of different options concerning the placement of the percussion point listed in (Tab.26) mirrors the technological repertoire the knapper has for producing variable blank forms. In order to obtain narrow elongated blanks, the blow is preferentially set below a central guiding ridge whereas for the production of wider flakes a more variable spectrum of gestures was possible.

Identifying preferential Levallois flakes within assemblages which are dominated by unidirectional scar patterns is difficult. Blanks with alternative scar arrangements can be seen as likely indicators for the application of the lineal method. The lineal flake cores exhibit centripetal scar patterns, and therefore, flakes and blades with similar patterns are corresponding end-products. Figure 60 shows that blanks with semi-centripetal and centripetal patterns are scarce. This suggests that the lineal method for flake production was rarely applied in point-dominated assemblages. Contrarily, the large and relatively broad Levallois flakes with semi-centripetal and centripetal scar patterns in the lower sequence are hints at a systematic production of one preferential flake per core (Fig.74, Nr.2-3). Alternatively, the large-sized blades which exhibit a unidirectional or bidirectional pattern represent the early stage of a recurrent production of thick and elongated blanks (Fig.74, Nr.1). Due to the fact that centripetal scar patterns seem to be restricted to broad Levallois flakes of variable size, it can be assumed that the lineal method was exclusively applied for the production of this blank type. Contrary to overlying point-bearing assemblages, the lineal and recurrent Levallois methods seem to represent separate reduction strategies which were rather not applied as two technical options within one and the same core reduction sequence. Unfortunately, the low sample size in levels 5e to 5g prohibits a more comprehensive reconstruction of technological gestures.

6.5.3 Summary

The high frequency of Levallois points in the majority of analyzed assemblages shows that the upper two third of the Hummal sequence can be characterized as a point-dominated Mousterian. A reliable assessment of the importance of Levallois point production should include all Levallois flakes with a convergent scar pattern. The frequency of respective flakes indicates that in levels 5AI to 5E around a half or more Levallois blanks were produced by the unidirectional convergent method. Two basic varieties of this method were applied, the recurrent and lineal flaking strategy. Both varieties are hardly differentiable without refitting. The Levallois points of the uppermost Mousterian levels 5AI to 5AVI show a bundle of technological features which reflect one of the two varieties of recurrent Levallois point production in Hummal. These points exhibit a broad base, large-sized butts with a *chapeau de gendarme*, and frequently more than three strongly converging negatives on their dorsal face. Contrarily, many narrow, “leaf-shaped” points in underlying levels are results of a recurrent method which worked with a narrow striking platform and convergent to parallel scar patterns. Preferential and recurrent points were produced on the same core within one reduction sequence. The intrinsic connection between both flaking strategies underlines the technological flexibility of the Levallois point concept. This flexibility is further demonstrated by the secondary production of Levallois points on flakes for which different kinds of flake blanks were produced or recycled. The focus on the unidirectional convergent flaking method, which is reflected by the majority of the assemblages, places Hummal in the group of other point-dominated Levantine Mousterian sites. The question of which sites are closest to Hummal in a techno-typological sense is dealt with in chapter 9.

Levallois flake and blade production in Hummal follows different technological concepts and is of variable importance across the Mousterian sequence. In point-dominated assemblages, a strong connection of Levallois points and the flake-blade group is evidenced by the fact that many of the latter are by-products of point production. Furthermore, the majority of Levallois flakes and blades were produced by the unidirectional-parallel flaking method which is technologically very close to the unidirectional convergent method. Polygonal and quadrangular shaped flakes are the most typical alternative end-products in point bearing tool-kits. The lowermost part of the Mousterian sequence revealed assemblages which are characterized by large flakes and blades. They demonstrate the use of a wider spectrum of flaking techniques ranging from a centripetal to unidirectional reduction of Levallois cores. It was probably the desired type of blank which guided the choice of flaking methods, whereby broad, polygonal flakes were struck from centripetally prepared cores and blades from unidirectionally prepared flaking surfaces. The marked elongation as well as the high faceting index of flake and blade assemblages are common features in all Mousterian levels.

6.6 Core trimming elements

As already mentioned, it is difficult to make a clear connection between certain types of core trimming elements (CTE) and a specific method of core reduction, especially within the Levallois concept. As the majority of blanks are Levallois points, flakes and blades, it can be assumed that the bulk of CTE are by-products which are related to the Levallois method of core reduction. While the functional interpretation of some CTE types, such as twisted core edge flakes and plunging blades, can be confined to the process of Levallois point production, other preparation flakes are diagnostic in respect to their function but non-diagnostic in respect to a certain Levallois method.

To follow the temporal order of core reduction, artifact categories will be presented in their chronological sequence whenever possible. All identified CTE types are listed in Table 27. Their butt configuration is given in Table 28. Both technological features are important for the chronological ordering of CTE groups and the core area from which they were struck. Altogether, 1518 analyzable core trimming elements were found. The function of about one-third of all CTEs is unclear; they are labelled as "core trimming elements *sensu largo*". They are probably remains from either striking platform or flaking surface preparation, as their mean size falls into the range of the respective artifact categories (Tab.27).

Figure 75 shows the range of surface size values for different CTE categories. The observed variability between the categories is caused by their staggered temporal position in the reduction continuum as well as in technological function. Some CTEs reflect an intention to remove a considerable flint mass, as in initialization flakes or core tablets, whereas others correlate with the contrary, in the sense that too large a removal would destroy the necessary structure of the flaking or striking surface.

6.6.1 First flakes and core initialization flakes

By far the largest CTEs are related to the earliest core reduction stage, as first flakes or core initialization flakes (Fig.75). Both categories are rare as only a few of them fall out during a reduction sequence. Moreover, the scarcity of first flakes in the analyzed assemblages is related to the fact that flint nodules were principally prepared at workshop localities outside of Hummal (chapter 7 and chapter 8). Due to the variable morphology of flint nodules and cores, both categories display a strong variability in size, whereby first flakes can be very small. Their marked thickness compared to other CTEs shows that a considerable volume of flint was removed. Having the same technological function, the difference between first flakes and core initialization flakes refers to the moment of production and the amount of cortex cover on raw material blocks. Both are the first flakes that are struck when a new flaking surface is opened. This can be done on a fresh nodule, in which case first flakes with 100% cortex cover accrue, or on already reduced cores with the intention of exploiting a new surface.[15] In the latter case, initialization flakes with a partial cortex cover, or without cortex, accumulate as by-products. Initialization flakes with a weathered surface or neocortex accumulate following the initialization of thermally altered nodules or of blocks collected in secondary outcrops. As fresh flint nodules are normally covered with cortex, the butts of first flakes consist of this material, with the exception of when the blow was set on a natural fracture plane. In this case, a splintering of the butt surface can occur. The initialization flakes show either plain or faceted butts, which indicates that a carefully prepared platform was not a necessary precondition for the opening of a new flaking surface.

6.6.2 Cortical flakes

When fresh flint nodules were initialized, the remaining cortex cover was removed. The resulting CTEs are cortical flakes. No conventional limit exists in relation to the amount of cortex required on a flake to warrant its attribution to this category (e.g. Andrefsky 2005, 115; Sullivan & Rozen 1985).[16] In the present study, all flaked items that exhibit 30% or more cortex cover on their dorsal surface are designated as cortical flakes. This limit was subjectively chosen on the basis of experience gained during analysis. On flakes with less than 30% cortical mass, the cortex mainly appears in isolated patches whose presence did not hamper blank production. Moreover, these small cortex remains often consist of material from the transitional zone between the outer chalky surface and the inner flint core. This transitional cortex zone has the same knapping quality as the flint core below and it was therefore not necessary to remove it.

Experimental studies have shown that cortical flakes can fall out at every stage of the reduction sequence (Sullivan & Rozen 1985; Ahler 1989; Tomka 1989). For this reason, it is

[15] The term “first flake” should not be confounded with the term “primary flake”, as the latter can possess variable amounts of cortex and is related the early phase of core reduction in a broader sense but not strictly to the very first removal. In French terminology, first flakes are termed *entames* or *éclats d’amorçage* (Brezillon 1983, 94).

[16] Sullivan & Rozen (1985) cautioned against using the amount of cortex as an exclusive variable to assess reduction stages as long as no replicable and standardized measurements exist thereof. The common line-up of primary, secondary and tertiary flakes with decreasing cortical mass to describe the sequencing of core reduction stages lacks clearly defined divisions between these categories. The French nomenclature reveals the same problem when separating *éclats corticaux* from *éclats semi-corticaux* (e.g. Boëda et al. 1990). Geneste (1985) differentiates between *éclats corticaux primaires* and *éclats corticaux secondaires*, with the latter having less than 50% cortex. Such flakes are often designated as *éclats d’épannelage*, stemming from a core trimming stage after decortication, whereas *éclats de décorticage* are related to the initial cortex removal (Brézillion 1983, 94). This distinction can be seen to correspond roughly to the sequencing of primary and secondary flakes.

difficult to differentiate between actual decortication flakes and later core trimming flakes. The cortical flakes listed in Table 27 are likely to be related to different core reduction stages. As a consequence, measured pieces show a wide distribution of size values above the median (Fig.75). In the present study, decortication flakes have been singled out more or less arbitrarily by setting a size limit of 5cm. As these flakes accumulate before actual blank production takes place, their butts are often plain or cortical. However, some pieces exhibit a faceted butt, which proves that a prepared striking platform was sometimes installed right from the beginning of core initialization to allow a controlled removal of the cortical surface. The mean flaking angle of early stage flakes is 110.5°, indicating that the flakes were struck from strongly bent surfaces.

Significant amounts of early stage flakes were found in high-density as well as low-density levels, with the exception of assemblages 5AIII and 5b6 (Fig.76). Because of their low sample sizes, the latter two cases are presumably not representative. Across the Mousterian sequence, cortical flakes account for 10 to 20% of all flaked items (fragments excluded), whereas around 50 to 60% are free of cortex. This frequency distribution shows that while decortication was a regularly performed activity in Hummal, its significance was generally low. Therefore, we can assume that the initial preparation of flint nodules took place elsewhere.

While the frequency distribution of cortical flakes is uniform, inter-assemblage variability exists within the cortical flake category. This variability, which is probably the result of different raw material import strategies, can be illustrated by two examples. An examination of cortical flakes in level 5a3 shows that about a half of them exhibit more than 50% cortex (Fig.77). Two peaks are visible for flakes with 50 to 60% and with 90 to 100% cortex cover. The second peak is caused by the transport of complete flint nodules to Hummal and their subsequent decortication. If we compare the bimodal distribution in level 5a3 with the unimodal distribution found in assemblage 5b5, the effect of different import modalities on the cortex distribution becomes visible (Fig.77). Core reduction in level 5b5 probably started with already prepared cores, and thus only one peak is given for flakes with 60 to 70% cortex, whereas true decortication flakes are scarce. The presence or absence of flakes with a high amount of cortex cover (≥ 50%) is used as one of several variables for the reconstruction of raw material import modalities in chapter 8.

Many broad and thick cortical flakes stem from the preparation of striking platforms around the circumference of Levallois cores (Meignen & Bar-Yosef 1991). Cortex residues are often left on the lower core surface. With increasing reduction, this surface has to be recurrently prepared to retain suitable flaking angles. During this procedure of striking-platform preparation, many removals extend to the centre of the lower core surface, thereby removing cortical residues when present. In doing so, the flaking surface serves as a striking platform, and therefore the butts of these cortical flake types are either plain or *dièdre*, consisting of former flake negatives. In addition, the flakes show a pronounced longitudinal curvature due to the convexity of the lower core surface, a feature that has to be retained throughout the reduction sequence. Curved specimens account for 40% among all cortical flakes, a remarkable number that indicates the presence of many striking-platform flakes in the cortical flake category.

Another type of cortical flake is the naturally backed knife (Fig.78, Nr.1-3). In typological studies, these flakes are seen as tools (e.g. Bordes' n° 38: *couteau à dos naturel*). This interpretation is based on the assumption that the blunt cortical edge opposite a sharp cortex-free edge is suitable for handling the cutting tool. Use-wear analyses seem to undermine this assumption by showing a preferential use of naturally backed knives for the cutting of soft materials (e.g. Lemorini et al. 2006; Rios et al. 2008). In a technological sense, naturally backed knives are preparation flakes which are struck mainly during the earlier phase of blank production as long as no supplementary striking platforms for a centripetal surface preparation are installed. Running parallel to the principal flaking axis, they remove the lateral side of the flaking surface to maintain the necessary convexities. Altogether, 37 naturally backed knives were identified, which, having a regular cutting edge and a pronounced cortical back, conform to the typological criteria (Bordes 1961b). As core reduction proceeds, naturally backed knives are replaced by core edge flakes having exactly the same function. Compared to the latter, backed knives are underrepresented, accounting for only 21% among all core edge flakes (Tab.27). Once again, this is evidence for the import of already prepared Levallois cores into the site. In the Hummal Mousterian, naturally backed knives and similar by-products, which do not conform to the typological definition, are typical preparation flakes, since Levallois blank production in most levels systematically followed a unidirectional or convergent concept. Overshot blades with a cortical back are typical by-products in the early stage of Levallois point production

The remaining flakes, with 30% to 50% of cortex, cover stem from the flaking surface preparation during advanced reduction stages. Their butts are mainly faceted, as they were struck from the principal as well as supplementary striking platforms.

6.6.3 Core tablets

At any given point in the reduction continuum, a total reorganization of the flaking surface could be necessary. This was the case when the required convexities could no longer be installed with other preparation flakes or when a major knapping accident happened. Removing a core tablet causes a considerable loss of flint mass, because the flake removes the whole flaking surface. It is difficult to differentiate between actual core tablets and plunging flakes that unintentionally removed a large part of the flaking surface. Intended core tablets are identifiable when traces of former flaking accidents are visible on their dorsal surface or when the blow occasioning their removal was controlled by guiding ridges (Fig.78, Nr.6).

Altogether, 15 core tablet specimens were identifiable. The majority were struck along the principal flaking axis, as is evidenced by a mean length-to-width ratio of 2.0 and a predominance of faceted butts. Both core tablets and plunging flakes remove a considerable part of the striking platforms' upper rim. This aspect makes core tablets interesting technological specimens, as they provide information on the shape of the flaking surface and the striking platform that is no longer given by exhausted cores.

6.6.4 Striking platform flakes

Right from the beginning of core reduction, the striking platform has to be recurrently prepared. The aim is to install a suitable flaking angle and a control point where the future blow is to fall. A tenth of all identifiable CTEs are attributable to this moment of the core trimming process. Striking platform flakes reveal distinct technological features. Their butts are mostly plain or of the *dièdre* type, as they were struck from the flaking surface onto the lower core surface. They are generally short and wide (mean LWR = 0.7), and compared to other CTEs they are the smallest preparation flakes to be found in assemblages when the smallest debris is excluded (Fig.75). To retain a suitable core volume, striking platform flakes should not extend over the whole lower core surface. Depending on the core's morphology, this was achieved by forming either a marked convexity or, contrarily, by leaving it completely flat. Due to the restricted blow extension, the flakes are short and exhibit the highest thickness at their proximal extremity (Fig.79). Many specimens retain cortex on their distal half and two or three negatives from a previous preparation sequence. To be frequently found as well are faceting scars on the proximal flake edge. The butt of many Levallois blanks shows a marked protuberance, which accords them a distinct profile called the *chapeau de gendarme*. This feature serves as a guide for the positioning of the future blow and is created by two adjacent striking platform flakes. These flakes were removed with a massive blow to obtain the necessary concavities. Striking platform flakes with a massive bulb can be related to this mode of platform shaping.

6.6.5 Core edge flakes

Core edge flakes have the same function as naturally backed knives and are their counterparts during the later stage of core reduction (Meignen & Bar-Yosef 1991). This is evidenced by the fact that both show a comparable width. However, backed knives are on average longer and thicker than core edge flakes (Tab.27). Core edge flakes were struck at the lateral extremities of the flaking surface alongside the core edge. Their function was to re-install lateral convexities of the flaking surface after recurrent blank production. Typologically, some core edge flakes correspond with pseudo-Levallois points. Two types of core edge flakes can be distinguished. One type exhibits the presence of one large flake scar stemming from a former blank removal and a significant part of the prepared lateral striking platform (Fig.78, Nr.4-5). On the other type, several small perpendicular flake scars stemming from preparation flakes are visible. Core edge flakes of this type initiated the sequence after a preparation of the flaking surface with (semi-)centripetal removals. In contrast to striking platform flakes, it was important that the force of the blow propagated over the complete length of the flaking surface. This aspect is reflected by a mean LWR of 1.9 for core edge flakes. At least 35% of all core edge flakes can be seen as by-products of the recurrent unidirectional convergent method. Their predetermining function was to set up the lateral convexity as well as the converging scar pattern on the cores' flaking surface. Being intercalated between the Levallois point removals, their dorsal surface bears the ridges left by these blank removals.

6.6.6 Abrasion flakes

Before each series of blank production, the obtruding flake scars left by earlier blank removals had to be removed. If these overhanging portions were left on the flaking surface, a controlled blank production would be seriously hampered as too much force is lost in these areas. An unequivocal identification of abrasion flakes which served this purpose is extremely difficult because these flakes resemble small blanks or bladelets. This is because their placement and mode of production is exactly the same as for blanks. For this reason, only six such specimens were identified.

6.6.7 Flaking surface preparation flakes

About one-third of all CTEs can be related to the preparation of the flaking surface. Their identification is not without problems, as there is an overlap between these preparation flakes and Levallois blanks. Many flaking-surface flakes lack the bundle of technological features that are typical for blanks (e.g. standardized morphology, longitudinal symmetry, use of ridges as guides), in which case their identification is facilitated (Fig.80). Nevertheless, it must be recognized that a number of blanks are erroneously attributed to this CTE category and *vice versa*. This especially concerns non-Levallois blanks smaller than 4cm that were produced at the final stage of core reduction.

Following Boëda's definition of the lineal and recurrent Levallois method (Boëda 1982, 1990, 1994, 1995; Boëda et al. 1990), these flakes are seen to belong to the reinstallation of the flaking surface after each series of Levallois blank removals. The preparatory purpose can be multifold. A re-shaping of the flaking surface becomes necessary when the required convexities are no longer present. Lateral convexities can be created by *débordant* flakes which are removed from the striking platform, which is also used for blank production. In this case, backed knives or core edge flakes are produced, and these represent separate CTE categories. Alternatively, within the recurrent Levallois flake and blade method, a convex flaking surface can be shaped with relatively small centripetal removals. In this case, the preparation flakes are struck either from a restricted part of the core or its total circumference (Fig.81). The high number of flaking surface flakes with faceted butts indicates that supplementary striking platforms were frequently prepared for the removal of these flakes (Tab.28). Less often, the blow was set on plain or cortical core edges.

Another function of flaking-surface flakes was to create a suitable scar pattern on the core to allow a controlled removal of Levallois blanks. It is this type of CTE which most resembles Levallois flakes, so that they are hardly distinguishable from them. To hold volume loss low, these flakes were struck in the same fashion as Levallois flakes with a fracture plane more or less parallel to the core's intersection plane, from faceted striking platforms. Probably the best discriminating feature between these flakes and Levallois blanks is the presence or absence of guiding ridges (Tab.29). As we have seen, for the majority of Levallois blanks, the blow is set below one ridge or between two ridges. While the majority of flaking-surface flakes were equally struck below a guiding ridge, a significant number show an off-ridge orientation or completely lack any proximal ridges. These flakes can therefore not be designated as predetermined products and rather had a predetermining function. The ridge-guided faceted flakes, which account for 60% of all flaking surface flakes, resemble Levallois blanks and can therefore be seen as "non-Levallois" blanks in respect to their technological configuration. Another function of some of the flaking-surface flakes was to remove traces of flaking accidents which hampered the continuation of blank production. Flakes which were struck for this purpose show the negative of hinge or step fractures on their dorsal surface. While flaking-surface flakes can serve for the correction of former accidents, the knapper had to avoid even more accidents that might arise from the removal of these flakes. In most instances, Mousterian flintknappers managed to do so, and only four flakes are plunging flakes. Another risk was that the flakes would not feather out and end as stepped or hinged flakes. That this danger was constantly present is evidenced by 68 flaking accidents, accounting for 15% of all preparation flakes.

6.6.8 Core trimming flakes sensu largo

This category comprises all flakes that were not attributable to any of the categories described above. It is an amalgamation of probable CTEs that lack a distinct feature, such as flaking surface flakes, striking platform flakes and abrasion flakes.

6.7 Non-Levallois reduction strategies

It has already been outlined that the Levallois method of core reduction was accompanied by alternative strategies of blank production. The decision to use a non-Levallois method was either guided by the type of raw material or the reduction stage of already used raw material blocks. Evidence for the procurement of limestone is scarce throughout the Mousterian sequence (Tab.30). Large pebbles were collected for the manufacture of pebble tools, but a few limestone flakes prove that some were also taken for blank production. Defining its technological process is severely hampered by the small sample size concerning limestone flakes. The same holds true for a few prismatic non-Levallois blades and corresponding cores made of Eocene flint. The question here is whether these pieces represent incidental changes within the Levallois method or a true, alternative strategy of blade production. Evidence of the use of flakes and flake fragments for a secondary blank production was found in every Mousterian level. The cores on flakes mirror a broad spectrum of reduction intensities and strategies. It ranges from fully exploited Levallois cores to minimally and opportunistically reduced parent flakes. Another systematically applied non-Levallois technique was applied for the purpose to extend the use-life of Levallois cores. We have already seen that Levallois point and flake cores were exploited until a certain threshold in the volume and morphometric configuration was reached. A few cores were then abandoned but the majority was further reduced by opportunistic flake removals. Given the fact that this form of core reduction was frequently very short and comprised only a brief moment in the total *chaîne operatoire* many of these cores still retain traces of the formerly applied Levallois method. However, as their final stage of exploitation did not follow the structured algorithm of the Levallois technique, they can in a strict sense not be designated as Levallois cores anymore. Thus, they are referred to as “simple flake cores” in the present study.

6.7.1 The opportunistic method of core reduction

The transformation of Levallois cores into simple flake cores marks a moment in the reduction sequence at which the degree of volume loss or flaking accidents made a further Levallois blank production impossible. The knapper had the choice between abandoning the core and exploiting the remaining flint mass in an opportunistic way.

Altogether, 50 exhausted simple flake cores were found in 16 out of 32 archaeological levels together with 14 pieces stemming from grouped levels (Tab.15). They account for 27% of the whole core sample and in most assemblages they occur in higher numbers than Levallois cores. An outstanding case is level 5b3 which revealed about four times more flake cores than Levallois types. A comparison of Levallois cores and simple flake cores in respect to their volume shows that the majority of the latter are considerably smaller (Fig.82). The smallest flake core found measures 3 x 2 x 1.5 cm and delivered a minuscule flake blank with a size of 1.3 x 0.9cm (Fig.83, Nr.3). The size difference between simple flake cores and Levallois specimens and the higher number of the former is an indication that the exploitation of Levallois cores in an opportunistic way prior to their abandonment was a systematically applied procedure.

Opportunistic flake production generally proceeded from one facetted striking platform; specimens showing more than one platform are rare (15%). Flake cores for which the former Levallois striking platform was no longer used frequently exhibit flake removals from unprepared platforms. They generally consist of former negatives (36%), cortex (4%) or cleavages (2%). Flake production was either done by re-using the former Levallois flaking surface or by rotating the core away from the principal former flaking axis towards remaining convexities which allowed for a further production of small blanks. In the latter case, the abandoned flake cores exhibit removals situated perpendicular or opposed to the remaining negatives left by anterior Levallois blanks. The cores which show a continued production in the same flaking axis lack any signs for a reinstallation of necessary convexities. Resulting waste cores frequently exhibit a series of overlapping hinge fractures (Fig.83, Nr. 2-3). In some cases, the opportunistic reduction extended on both core surfaces leaving behind small, discoid-like flake cores showing alternating blank removals (Fig.83, Nr.4).

Unfortunately, it is so far impossible to identify the end-products of this arbitrary core reduction method. They should be looked for in flake samples within the 2-3cm size range. However, without the help of refittings it will probably be impossible to distinguish between these small flake blanks and surface trimming flakes. As we have already seen, many flakes in the latter group were struck from supplementary striking platforms and thus exhibit facetted butts, and therefore, this feature is not a discriminating variable (see also Van Peer 1992).

The non-Levallois blank sample listed in Table 14 consists of 78 flakes and blades and 43 Kombewa flakes. It should be noted that except for the Kombewa flakes, the non-Levallois blank group represents a kind of “melting pot” containing artifacts of which the technological context is unclear. Some appear Levallois-like but lack facetted butts, a morphological symmetry or signs of predetermination, such as blow-guiding scars or preparative removals. A significant portion of these flakes can potentially be seen as CTEs which were erroneously classified as blanks. However, the smaller pieces which have a size below 5cm and account for 38% are likely results of the final opportunistic blank production.

6.8 Blank production with cores on flakes

As can be seen in Table 15, cores on flakes are the predominant core type found in most levels. Two major reduction concepts are deducible from the technological analysis of cores on flakes and the end-products produced on them. It has already been shown in chapter 6.5.1 that large flakes and flake fragments were used for a production of Levallois points. In these cases, it was the ventral surface which offered enough volume to be exploited, and the reduction process involved all preparation steps typical for the unidirectional convergent Levallois method. The significance of cores on flakes for the recurrent production of Levallois blanks is difficult to assess because reduction was often pushed to the extreme making it impossible to decide whether a given core was made out of a flake or other forms of working pieces. Levallois points were quickly obtained after at least two anterior removals (Kombewa and Janus flake), which shows the efficiency of flakes for Levallois blank production. For the moment, it is not possible to reconstruct the actual technological status of Kombewa and Janus flakes which were found in the Mousterian assemblages. Were they only by-products of Levallois point production or alternative end-products, and was their removal always related to the application of the unidirectional convergent Levallois method on flakes? Although the scarcity of Kombewa and Janus flakes could indeed be taken as an indication for their role as by-products, this assumption is doubtful. The discovery of flakes from which one or more Kombewa flakes were removed without the aim to initiate a Levallois reduction sequence proves that the exploitation of a flake’s ventral surface represents an alternative non-Levallois method of blank production. The importance of secondary non-Levallois flakes is further corroborated by the fact that a considerable number were also obtained from the dorsal face of suitable flake blanks. Leaving the more complex Levallois cores aside, the remaining cores on flakes do not reveal any conceptual difference between the exploitation of the ventral and dorsal surface of flakes. Blanks with a sufficient volume were chosen from the lithic waste and a prepared or natural striking platform served for the production of one or more small flakes. This technological homology is undermined by the presence of pieces which exhibit an exploitation of both faces. Compared to the Levallois method, the production of non-Levallois flakes on flake blanks does not represent an equivalent reduction process in the *chaîne opératoire*. The majority of cores on flakes and corresponding end-products are results of a recycling process in which artifacts produced by the Levallois method were re-used. While some large flakes were exclusively produced in order to serve as Levallois point cores, the bulk of cores on flakes mirror an economic strategy which aims at increasing the efficiency of raw material exploitation. Their overwhelming presence in all Mousterian assemblages generates the impression that flint constituted a critical resource in the technological organization of the occupants in Hummal and its productivity had therefore to be maximized. However, the significance of cores on flakes is not sufficiently explained by the maximization of a flake's utility alone. The end-products obtained within the recycling process must have represented a desired additional component in the repertoire of implements which were principally designed by the Levallois method. These secondary flakes and the cores from which they were struck are the focus of this chapter. A review of the publications dealing with secondary flaking techniques shows that apart from the Kombewa method, the techno-typological significance of cores on flakes is still not well understood and remains a subject of ongoing debates (e.g. McPherron 2007). Therefore, additional information can be offered with the data derived from the Hummal assemblages. Before presenting them in detail, a short sketch of the research that has already been done on this issue will be given in the following section.

6.8.1 Different perspectives on the same problem: how to recognize and evaluate the core on flake phenomenon?

In their discussion about cores on flakes and the problem of their identification in lithic assemblages, Dibble and McPherron point out that

"… [the] *study of truncated-faceted pieces and their products highlights the problem we, as archaeologists, face in recognizing behaviorally significant components of lithic assemblages. However open-minded and observant we try to be, the simple fact is that our observations, and therefore our interpretations, are very much dependent on the range and kinds of categories that we ought to see*." (Dibble & McPherron. 2007, 87)

The premonition that we still overlook many phenomena in lithic assemblages because of too rigid analytical approaches or classification systems being out of date is a problem which is well known to every researcher doing lithic analysis. Recapitulating the ongoing debate about secondary flaking techniques illustrates very well how innovative and traditional approaches look at an artifact category from very different viewpoints. An analytical problem arises when the chosen viewpoint incorporates a too restricted definition of the relevant artifact category. Concerning Mousterian assemblages, tools are frequently put into small-meshed type cases whereas cores are assigned to broadly defined groups because of their morphological variability. Dibble and McPherron's statement is all the more important as it circumscribes an analytical problem which also surrounds the analysis of secondarily reduced flakes. Typological approaches which focus on the detection of certain tool types often classified these artifacts as a distinct tool category, whereas technological approaches tend to consider them as cores.[17] An inductive approach which considers secondarily reduced flakes *a priori* as tools or cores, inevitably works with attributes being specific for the former or the latter. If an analysis works with a too restricted set of attributes, it runs the risk of missing the significance of the subject at hand.

Relatively recently, Paleolithic archaeologists became aware that the strategy to reuse flakes as cores was a significant component of past human behavior. In fact, cores on flakes and the respective end-products have been overlooked in many instances, probably because of their size being frequently small and the fact that many cores exhibit traces of a restricted, opportunistic reduction (Dibble 2006). An array of articles describing the use of flakes as cores in different regional and chronological contexts reveals the complexity of the phenomenon (e.g. Bourguignon & Turq 2003; Bourguignon et al. 2004; Geneste & Plisson 1999; Goren-Inbar 1988; Newcomer & Hivernel-Guerre 1974; Hovers 2007, 2009; Park 2008) In the following sections, it is not intended to recount all existing interpretations surrounding the phenomenon of secondarily reduced flakes, but to look more closely at the diversity of cores on flakes and the possibility to identify them in artifact collections. Further, it is not my aim to deliver a comprehensive description and classification of cores on flakes, as they are geographically and temporally widespread. Thus, their interpretation should always be set against the respective geographical and chronological context. In the present case, we will restrict the matter to Mousterian assemblages from the Middle East.

[17] Interpreting secondarily reduced flakes as a special tool type seemed warranted when technological features such as visible flake scars and faceted striking platforms, often in combination with retouch on one or more edges, were clearly visible. Consequently, they were presented as burin types, *Nahr Ibrahim* tools, truncated-faceted pieces or *Kostienki* knives.

As cores on flake have not been considered as such in many former analyses, the respective original designations are retained in this section. This is done to avoid confusion as every researcher's specific point of view influences the identification of the relevant pieces in an assemblage. A researcher considering cores on flake as tools probably does not obtain the same frequencies as does someone who views them as cores. [18] In his presentation of the Mousterian assemblages of Jerf al Ajla, Schroeder (1969) delivered a detailed description and classification of secondarily reduced flakes, calling them "truncated-faceted pieces". The term is still used in recent analyses or handbooks of typology (e.g. Debénath & Dibble 1994, 123; Dibble & McPherron 2007). As a common trait, Schroeder recognizes the faceted butt placed on a truncation. A distinction can be made between truncated-faceted pieces with flake removals on their dorsal or ventral surface and on the basis of the striking platform's location (proximal, distal and lateral). Schroeder does not commit himself on a definite functional interpretation, but in his opinion, the flake blanks' flatness supports an interpretation as thinned or straightened flakes for whatever purpose (Schroeder 1969, 398). Analysis of the blank form revealed that truncated-faceted pieces virtually cross-cut all artifact categories and tool types. This observation and the fact that they occur in significant numbers throughout the Jerf Ajla sequence indicates as strong continuity of this special flaking technique. Nevertheless, Schroeder underscores a clear-cut distinction between truncated-faceted pieces and basally thinned *Emireh* points on the basis of the modification's "delicacy" (Schroeder 1969, 399).

Solecki & Solecki (1970) described the truncated-faceted pieces found in the assemblages of the Nahr Ibrahim Cave in Lebanon. They not only distinguished several types, but described the technique as a whole, calling it "*Nahr Ibrahim* technique". Like Schroeder (1969), they identified the common principle of this flaking technique: a truncation on a flake was faceted to obtain a striking platform for subsequent flake removal(s) on the dorsal surface of the flake (Solecki et al. 1970, 137). On the basis of the platforms' frequency and location as well as reduction intensity six *Nahr Ibrahim* types were differentiated (types I-VI). The authors remained cautious about a functional interpretation of the *Nahr Ibrahim* types. Depending on the type, they see-saw between an interpretation as cores, notched tools or thinned artifacts for hafting. Due to their systematic occurrence in Middle Eastern Mousterian

[18] In fact, the first who recognized the reuse of flakes or blades for blank production as a systematic phenomenon in different cultural contexts were M.H. Newcomer and F. Hivernel-Guerre, who published their results based on the study of cores on flakes from the Gamble's Cave material in Kenya (Newcomer & Hivernel-Guerre 1974). Apart from describing the technological process of this secondary flaking method, they tried to define the borderline between cores on flakes and tools in order to identify possible differences which they saw to constitute the variability of one general technological concept.

assemblages, the authors saw the *Nahr Ibrahim* types to be potential cultural or chronological markers, without further engaging these thoughts. Like Schroeder, they postulate a clear difference between these types and the *Emireh* point, whose proximal thinning is considered a hafting device. The technique being the same, a technological evolution from the *Nahr Ibrahim* types to the *Emireh* points is presented as a working hypothesis.

In his analysis of the Rosh Ein Mor assemblage, Crew states that truncated faceted pieces "*… cannot validly be called tools, since it is their mode of manufacture which sets them apart. A blank is first roughly truncated, and the truncated surface then serves as the platform for subsequent flake removals. The removed flakes are generally quite small and on the dorsal surface. While the technique is the same as the process of removing a flake off a core, the resulting pieces are usually so small that it is difficult to see any use for them.*" (Crew 1975, 109). Following this observation, he considers hafting as a possible explanation but found no wear traces on the edges of the truncated-faceted pieces. The frequency of pieces with a faceted truncation in the Rosh Ein Mor assemblage (75%) prompted Crew to see their function as cores. It is interesting to note that he observes a grey area between truncated-faceted pieces and the so-called *burin à face plan* when flake removals are visible on the lateral edge of a flake.

The first extensive technological study of secondarily reduced flakes was accomplished with the Mousterian material of Keoue Cave. Nishiaki (1985) searched for metric trends and a possible discrimination between truncated-faceted pieces and other artifact types on the basis of certain attributes. Given that the flakes modified by a faceted truncation were always large-sized, Nishiaki postulates a common choice of such flakes for the fabrication of retouched tools and truncated-faceted pieces. Among the latter he distinguishes eight categories depending on the location of secondary flake removals in respect to the original flaking axis (Nishiaki 1985, Tab.5, p. 219). To better define these categories, variables like surface size, number and flaking angle of the secondary flake removals are examined. On the basis of certain attribute combinations, Nishiaki postulates a cultural relationship between the Keoue and Jerf Ajla assemblages.[19] With respect to possible functional interpretations, Nishiaki tries to avoid an unequivocal definition, pointing at the variability among these artifacts. Proximally modified items are seen as cores if they exhibit "large enough" flake scars.

[19] It has to be mentioned that only 39 truncated-faceted pieces have been found in the Keoue assemblage. In my opinion, this small sample size is not sufficient to deal with the question of common technological traditions. Despite the low sample size, Nishiaki's analysis is to be prized for its detailed data presentation and discussion of analytical variables.

M.H. Newcomer and F. Hivernel-Guerre (1974) were the first to propose that the so-called *Nahr Ibrahim* tools and truncated-faceted pieces are actually cores. Following this proposition, N. Goren-Inbar (1988) identified cores made on flakes in the Quneitra sample and presented their techno-typological characteristics. The results show that the recognition of cores on flakes in an assemblage can profoundly change our understanding of the variability inherent in Mousterian reduction processes and raw material economy.

In recent case studies done be E. Hovers (2007, 2009) on cores on flakes from the Amud B1, B2 and B4 and the Qafzeh assemblages as well as by D.O. Henry (2003) in the site of Tor Faraj illustrates the operational process they are related to.[20] The results undermine the complexity of this artifact category both from an intra- and inter-assemblage perspective. In Amud Cave, flakes have been taken for blank removal in nearly the same way than nodules are. As a consequence, the complex interrelation of technological parameters in the use of the Levallois technique applies for both core forms. Trying to assess the significance of cores on flakes in the Mousterian technological organization, Hovers and Henry examine the correlation between raw material supply and the frequency of reused flakes. Interestingly, a simple distance-decay model and deferred curation model did not deliver plausible explanations for their frequency in Amud, Qafzeh and other Levantine Mousterian sites (e.g. Quneitra, Tor Faraj, Rosh Ein Mor). Moreover, a rather expedient secondary flaking technique is represented by the Amud material. In contrast, causal relationship seems to underlay the frequency of reused flakes and the raw material-deprived surrounding of Tor Faraj. Thus, the reuse of flakes as cores can be simply an answer to raw material shortages, but it has to be assumed that in many instances a variety of other factors triggered this kind of raw material exploitation. Such can be mobility patterns, tradition, task-related requirements, efficiency, and others.

6.8.2 Cores on flakes or tools?

A crucial question concerning the techno-typological interpretation of secondarily reduced flakes is whether these pieces are to be seen as tools or cores. As we have seen, previous studies either made no attempt to answer this question by concentrating on classification criteria alone, or were at least ambiguous in the sense that some specimens were seen as tools and others as cores depending on the intensity of reduction and presence of retouch.

[20] In her analysis, Hovers reduces the definition of cores on flakes to two principal parameters: three or more blank removals have to be visible, and they need not be spatially separated (Hovers 2007, 45). This limitation shall avoid the confusion with certain tools or accidentally derived pieces by miss-hits or edge damage for example. The problem with this limitation is that a large part of cores on flakes is excluded; for example, a Kombewa core would apparently not be included in this definition. Under the premise that cores on flakes are treated the same way than nodule cores are, we should allow for a significant variability of scar counts and patterns on the former.

Circumscribing the "cores on flake" phenomenon becomes problematic when trying to separate it from objects which have been modified in a similar way but for other purposes, like hafting devices or special tools (notches, burins, *Kostienki* knives, etc.). The reason for the existing terminological and typological inconsistency is grounded in the variability of cores on flakes in respect to the morphology of chosen flake blanks and the wide spectrum of possible reduction strategies (see also Goren-Inbar 1988).

To undermine an interpretation of secondarily reduced flakes as cores, other possible explanations must be ruled out on the basis of objective criteria. This concerns the hafting hypothesis and ergonomic considerations in the sense of thinning an alleged tool for better handling. It is not intended to deny the existence of hafted tools in the Hummal assemblages, but to separate them from cores on flakes with the help of specific attributes. In his study of the Bisitun Cave assemblages, Dibble (1984) mentions two important aspects which, in his view, contradict the hafting hypothesis related to truncated-faceted pieces. First, the apparently random choice of blanks and inclusion of debitage categories which would otherwise not be considered as tools speaks against a thinning technique applied to certain tool types. Second, it is hard to imagine the hafting of pieces with more than one truncation, often opposed to each other. In light of the secondarily reduced flakes in the Hummal sample, I agree with Dibble and propose some further considerations, which are of importance. First, if an artifact is thinned by the removal of small flakes for the purpose of hafting, it should exhibit a smooth surface and regular shape in the respective area. If central ridges and concavities formed by the secondary flake negatives are left over, the hafting device will be worn off quickly or damaged.[21] This aspect can be illustrated by two examples. The first is a large double side scraper made on a Levallois blade which exhibits a thinned base created by several minuscule removals (Fig.84, Nr.1). Due to the small size and considerable overlap of these proximal flake scars, the function of the scraper as a secondary core is unlikely. The smooth and pointed shape of its thinned base is rather to be seen as a hafting device. In addition, a certain number of Levallois points show an abrupt truncation all along their proximal edge from which no further flakes were removed on the dorsal face. These implements resemble *Emireh* points and the thinning on their ventral surface is probably to be seen as a hafting device (Fig.137, Nr.1). The second example is a broken simple side scraper which was recycled into a core on flake (Fig.84, Nr.2). Two striking platforms were summarily prepared on the breaking surfaces and at least two blanks were removed in a bidirectional fashion. If the core's proximal part is

[21] Under this premise, cores on flakes in Mousterian assemblages from La Ferrassie, Le Moustier and Pech de l'Azé IV have been investigated and separated from thinned tools at the Musée de Les Eyzies in France. I want to thank A. Turq and J.-Ph. Faivre for the lively discussion about this matter and their readiness to examine the material together with the author.

examined more closely in plan view, a prominent central ridge is visible which is left by the secondary removals. The presence of this ridge which would interfere with any hafting procedure and the size as well as arrangement of the secondary removals supports an interpretation as a core on flake.

Apart from the nature of the reduced section, its location in respect to the active part of the artifact can be another discriminating attribute for the differentiation between hafting devices and cores on flakes. The hafting hypothesis is only plausible for cases in which the thinned or over-worked part (the "*contact réceptif*" in the French terminology) stands in a technological relationship to the active part (the "*contact transformatif*") of the tool. In other words, the hafting device must be positioned in such a way as to guarantee an optimal function of the tool. Flakes which exhibit secondary flake scars in the sector of an active part, such as a sharp or retouched edge, are to be seen as cores on flakes rather than thinned tools. The thinning of implements for hafting more likely occurs in a section located opposed to the tool's active part, such as the proximal extremity or one of the lateral edges. Although a certain number of cores on flakes reveal such associations, the gradual shift towards pieces showing identical flake removals but lacking such associations is significant. Solecki & Solecki (1970) described such examples as "core-like" pieces with three or more truncated faceted platforms (type V in their classification).[22] All the above mentioned considerations should be tested by conducting a use wear analysis on the respective artifacts. Use wear studies apparently confirmed the hafting hypothesis concerning truncated-faceted artifacts found in several Mousterian layers of Umm El Tlel (Bonilauri cited in Boëda et al. 2001). Unfortunately, no further information concerning the truncated flake blanks and the configuration of their secondary removals is available so far.

A detailed investigation of cores on flakes reveals that many meet the typological criteria of certain tool types described by the classification system of Bordes (1961b). To

[22] From the neighbouring site Umm El Tlel, 124 *Nahr Ibrahim* pieces of layer VI 3a'1 have been taken for an analysis using the "*techno-fonctionnelle*" approach (Primault 1997). Apart from the presentation of a sample of 124 respective artifacts and noteworthy technological criteria, the rigid inductive reasoning inherent in this approach makes a comparative discussion of the data impossible. Using the *techno-fonctionnelle* approach presupposes that *Nahr Ibrahim* pieces are tools, otherwise the identification of so-called "unités techno-fonctionnelles" which try to explain the relation between certain morphological features, the intended use of the object and the way of using it, does not makes sense. Excluding *a priori* other possible interpretations, the comprehension of the *Nahr Ibrahim* type becomes too narrow. As a consequence, the studied sample is composed of *Nahr Ibrahim* types with a limited set of features, thereby excluding all other variants. The choice has been restricted to items with one or two faceted truncations and flake removals on the dorsal surface. The secondary flake removals are interpreted as a thinning of the piece for subsequent hafting. The technological analysis defines various cross section types and studies the intersection angle between the surfaces. To discriminate morphological patterns in this sense is in fact a useful practice, but the results should be correlated with more than just one possible interpretation of the *Nahr Ibrahim* type.

mention in this respect is the side scraper with thinned back (*racloir à dos aminci*, Nr. 27), the atypical burin (*burin atypique*, Nr. 35), the notched piece (*outil à encoche*, Nr. 42), the denticulate (*outil deniticulé*, Nr. 43) as well as other types in which the modification was coarsely executed and consists of relatively large removals. A differentiation between actual tools and cores on flakes can be made by checking for the presence of secondary striking platforms, and by examining the size and location of the secondary removals. A further aspect to be considered is the tool's completeness, because broken tools lost their functional value and are therefore likely candidates for recycling. Many side scrapers with a thinned back are actually recycled tools of which the thickest section was suitable for further exploitation. Notched pieces, tools with a scraper-notch association, and denticulates with large, invasive negatives can be waste cores resulting from a secondary and even tertiary reduction process, as has been shown for some Quina Mousterian assemblages (Bourguignon et al. 2004; Hiscock et al. 2009). The exploitation of a lateral flake edges results in cores on flakes which resemble burins and atypical versions of this tool. The majority of alleged burins in the Hummal assemblages as well as in other sites where this tool type is abundant, such as the Mousterian assemblages of Yabroud, are better interpreted as recycled flakes for bladelet production.

6.8.3 Definition and classification of cores on flakes

Each flake which exhibits at least one distinct scar left by a blank removal was considered as a core on flake. We are aware that the inclusion of pieces with one isolated negative bears the risk of dealing with incidentally produced "cores on flakes". It has been observed that the production of a flake sometimes results in the removal of an accidental, secondary flake (Dag & Goren-Inbar 2001, cited in Hovers 2009). This incidental flake removal often occurs in the bulbar area and the corresponding piece therefore resembles a Kombewa flake. An accidental bulb removal was found on 7.4% of all analyzed artifacts whereby the affected area shows either small negatives or a Kombewa-like flake which still adheres to the ventral surface (Fig.85). While it is true that some of these pieces are likely to be confound with true Kombewa cores, especially when the negative is large, an exclusion of cores with only one negative from analysis would ignore a significant amount of secondarily exploited flakes, and thus reduce the informative potential of raw material recycling in Hummal (contra Hovers 2009). Furthermore, most of the Kombewa flakes were produced after a striking platform had been prepared, which shows that a secondary flake was intentionally removed.

Although many attempts have already been made to classify artifacts with secondary flake removals, it is warranted to propose a new definition on the basis of cores on flakes which were found in Hummal. We have chosen to use the exploited face of the parent flake as a feature for the definition of different core on flake types:

1) ventral cores: this group contains all flakes which were exploited on their ventral surface (Fig.86, Nr.1-3, 6, 8); comprising it are classical Kombewa cores and Janus-type cores.
2) dorsal cores: when the parent flake shows traces of one or several secondary blank removals on its dorsal surface it is classified as a dorsal core (Fig.86, Nr. 4, 7, 10, 11); this group includes the classical *Nahr Ibrahim* core types defined by Solecki & Solecki (1970).
3) multiple cores: this group comprises all cores on flakes which show a secondary exploitation of the dorsal as well as ventral surface (Fig.86, Nr. 3, 9).

The intensity and strategy of reduction are variable within each group. The identified flaking methods range from opportunistic isolated flake removals to more elaborate techniques like the Levallois method. The group of ventral cores, for instance, includes simple Kombewa types as well as Levallois cores, which have already been presented in chapter 6.5.1 and Figure 72.

6.8.4 Blank choice

The secondary exploitation of flakes is an efficient method of blank production because the preparation effort is significantly reduced. The flakes' dorsal and ventral surface already provide the necessary convexity and dorsal flake scars can be used as guiding ridges during flake removal. Apart from necessary convexities and usable scar patterns, the parent flake must exhibit a sufficient volume to allow for a reasonable blank return.

The possibility of determining the type of blank which was chosen for a secondary flake production depends on the intensity of exploitation. Extremely reduced pieces often display only a small remaining part of the original surface which precludes a detailed classification. One important feature is the blank's completeness because unbroken flakes can represent blanks which were exclusively produced to serve as cores whereas flake fragments definitely mirror the recycling of already used raw material. Analysis shows that the majority of secondary flakes were struck from broken blanks and tools (Fig.87). The frequency distribution of complete vs. broken blanks for each core on flake type in Table 31 shows that unmodified broken flakes were preferentially chosen as flake blanks independent of the exploitation strategy. Thus, the recycling of flakes and tools seems to have been an important factor in the Mousterian raw material economy. The frequency of recycled fragments could even be set higher because many cores on flakes exhibit faceted platforms which potentially blur former breaking surfaces. The exploitation of a flake's ventral surface requires it to be convex, and therefore, only complete flakes or proximal fragments were taken for that purpose. The dorsal surface is generally more convex than the ventral surface, and therefore it is not surprising that the choice of blanks for dorsal cores allows for a higher flexibility in respect to blank type. For the majority of cores on flakes, a typological classification of the recycled blank was not possible due to the intensity of reduction or because of non-diagnostic fragments. Hence, these flake blanks were designated as "flakes sensu largo" (Tab.32). A debitage category which played an important role in the recycling process is core trimming elements. In this category, many cortical flakes are found which reflect the preferential use of voluminous by-products from initial reduction stages (Fig.88). Likely, Levallois blanks and broken side scrapers seem to have been a preferred pool of suitable raw material.

In general, the chosen blanks are between 5 to 6cm long and 4 to 5cm wide (Tab.33). In order to have a sufficient volume at disposal, the blanks are thick with mean values over 10mm. These values show that only the thickest flakes were chosen from the debitage sample (Fig.89). As the production of Kombewa and Janus flakes necessitates a sufficiently convex ventral surface, the largest flake blanks were taken for this purpose (Fig.90). Their volume is significantly higher than that of dorsal cores (comparison of mean values: $t = -2.956$; $p=0.004$). In most instances, the blanks were probably taken from recently accumulated lithic waste as double patinated cores on flakes are rare (4.7%).

A comparison between cores on flake and Levallois cores exhibits a striking similarity regarding their size. Differences in length and width comprise no more than 5 mm. Levallois cores are generally thicker, which is related to the fact that they require a higher volume in order to apply the technological features of the Levallois method. Doing the same comparison with simple flake cores, different results are obtained. Simple flake cores are smaller and thicker than cores on flake. But metrical differences are all below 1 cm, and can therefore be explained by differential reduction intensities and a stronger variability among discarded flake cores. Raw material influence is negligible as all pieces are made on Eocene flint. Thus, we can infer that cores on flake and nodule cores show no discriminating metric features in respect to blank production at the end of their use life. A similar observation on even more intensively reduced cores has been made in the Quneitra assemblage (Goren-Inbar 1988).

6.8.5 Intensities and strategies of exploitation

Regardless of which surface was exploited, the direction of flake removals was generally oriented along the flaking axis of the blank (Fig.91). This is not surprising as most of the flake blanks and by-products of the Hummal Mousterian are elongated and a profitable secondary flake production reasonably focused on the blanks' largest extension. Moreover, the exploitation of the dorsal face frequently used the proximal-distal running flake scars as guiding ridges. The pattern of flaking directions in Figure 91 is caused by the presence of many dorsal cores on which blank removals followed the unidirectional convergent scar pattern of the flake blank. Therefore, the secondary flake scars frequently show inclinations in the range of 330° to 360° and 0° to 30°. A significant number of secondary flakes were struck from the distal extremity opposed to the blanks' flaking axis with an inclination between 165 and 194°. As most of the Levallois blanks and their by-products exhibit a thin, feathered termination which is not exploitable *per se*, secondary flake removals running opposed to the original flaking axis were found on blanks lacking their distal tip (58%) or on exceptionally thick specimens (42%). Cores on flakes with perpendicular running removals, which were struck from the lateral margin of a flake or fragment, are rare because the width offers the least potential for the production of adequately sized blanks in assemblages dominated by elongated blanks. An examination of the number of exploited sections within each core on flake category shows that most of the dorsal and ventral cores exhibit secondary removals confined to one part of the flake blank (Tab.34). It can be seen that the pattern of flaking directions is principally caused by proximally exploited dorsal cores and a few multiple cores with alternating removals in this part. The fact that these core types account for 50% of all cores on flakes shows that the recycling of broken flakes, of which the dorsal scar pattern allowed for an efficient flake production, was the dominant strategy. When complete flakes were exploited on their ventral surface, the secondary flakes were principally struck from their bulbar area as it is this part of the blank which has the highest volume and convexity. About one fifth of all dorsal and ventral cores show an exploitation of two or more adjacent or opposed sections. The majority of multiple cores exhibit secondary removals in unrelated sections on the dorsal and ventral surface.

The number and size of secondary scars are further variables to assess the reduction intensity of cores on flakes. The frequency of scar counts for each core on flake category is shown in Figure 92. Over 70% of the dorsal cores served for the production of only one or two blanks prior to their discard. About half of the ventral cores were equally exploited in a sparsely way. However, ventral surfaces on average seem to have been reduced more intensively than dorsal surfaces as can be seen by higher proportions of cores showing three or more negatives. Although sample size is small, the multiple cores seem to be represented by two different groups. One group is composed of cores with few isolated negatives whereas the other comprises intensively exploited specimens showing five or more flake scars. The maximum number of seven flake removals has been recorded for three dorsal and two ventral cores. These heavily reduced cores on flakes frequently bear traces of preparative removals and can therefore be seen as counterparts of simple flake and Levallois cores made on nodules, except for the fact that the latter generally allowed for a higher number of reduction series. The correlation between the number of flakes removed and secondary flake size shows a clear trend in the sense that the higher the number of secondary blanks produced the smaller they become (Fig.93). This relationship reminds one of the basic difference between the lineal and recurrent Levallois method, namely that a flaking surface can serve for the production of either one large flake or several smaller products. Nevertheless, the observed relationship is also partly caused by the measuring method because only the last removals which are often the smallest ones are complete and therefore measurable. The size of secondary negatives was measured in their greatest length and width. Table 35 shows the mean scar dimensions and LWR for all core on flake types. It can be seen that the secondary flakes were remarkably small falling into a size range between one and three centimeters. The mean LWRs do not reveal a significant variability between the core types, however, the median values and standard deviation show a stronger variability in the group of ventral cores than in the other categories. Hence, a broad spectrum between elongated and squat flakes was produced on the ventral surface of flake blanks, whereas the exploitation of the dorsal surface followed a more standardized pattern resulting in short flakes.

As has already been mentioned, the secondary flaking method involved only a minimal preparative effort. In most cases, a faceted striking platform was created with a few small removals to install a suitable platform angle (Tab.36). This aspect has been described as the basic feature of the *Nahr Ibrahim* technique (Solecki & Solecki 1970; Newcomer & Hivernel-Guerre 1974). Former negatives, breakages or cortical areas were only sporadically used without preparation. As soon as reduction proceeded in more than one blank section, additional unprepared platforms were often incorporated into the flaking process. The platform angles range between 60 and 75° which is identical to the range measured for simple flake cores and Levallois cores. Exterior platform angles being too low or insufficient convexities caused many secondary flake removals to end in hinge or step fractures. Traces of these flaking accidents are found on 51% of all cores on flakes, whereby hinge fractures are more common than stepped fractures (54% vs. 39%). Some cores on flakes were split into two halves in their longitudinal section (Fig.72, Nr.1). This Siret fracture has also been recorded in other core on flake-bearing assemblages (Demidenko & Usik 2003) and was probably caused by maladjustment of the blow in respect to the remaining core volume.

6.8.6 The end-products obtained from cores on flakes

The relatively high number of cores on flakes in all assemblages stands in a clear disparity to the low number of secondary flakes (Tab.14). Kombewa and Janus flakes account for only 4% of the whole debitage sample. Why is this flake category so rarely found in all levels? And does their scarcity imply that we have to see them as incidentally produced artifacts? Regarding the frequency of cores on flakes, the second question can be answered with “no”. The low number of secondary produced flakes can be explained by several factors.

Depending on the reduction of ventral cores, Kombewa and Janus flakes are identifiable by a ventral surface or remains of it on both faces (Fig.94). The stronger the reduction of ventral cores the more difficult it becomes to identify the corresponding Janus flakes because the amount of the original ventral surface is getting increasingly smaller. Thus, it is possible that a significant proportion of Janus flakes is yet unidentified. Concerning the dorsal cores, it was not possible to correlate any flake with this core type in the present state of analysis. The reason behind this visibility problem is the morphological congeniality between these secondary flakes and small Levallois products or core trimming elements. Most of the secondary flakes should exhibit a faceted butt and dorsal scar patterns which are not distinguishable from those of Levallois blanks or flaking surface flakes struck from Levallois cores. Future attempts to sort out potential secondary flakes should focus on flake samples in the lower size range. A second diagnostic feature can be hinge fractures, as many dorsal cores exhibit traces of this type of accident.

Altogether, 16 Kombewa and 28 Janus flakes, which are of variable size and morphology, have been found so far. Kombewa flakes are generally quadrangular to oval shaped and show a biconvex cross section. The morphology of Janus flakes is more variable and depends on the presence or absence of existing scars which were usable as guiding ridges. Some of the larger specimens seem to be related to the preparation of a flake’s ventral surface for Levallois point production (Fig.94, Nr.2). Both flake types have a mean size of about 4cm, however, the standard deviation of 1.9 and the minimum and maximum values indicate a strong variability (Tab.37). The mean thickness of 0.5 cm is comparable to that of Levallois flakes but the high RT value of 0.2 shows that these flakes are relatively thick in relation to their size (RT mean for Levallois flakes and blades: 0.1). In contrast to Levallois blanks, Kombewa and Janus flakes are generally squat as can be seen by the low mean LWR of 1.6. The mean edge angle of 33° is exactly the same as was recorded for Levallois blanks and this close resemblance shows that both artifact categories had a comparable edge performance. The majority of Janus flakes displays one or two negatives on their dorsal surface (31% and 21% respectively). This observation accords well with the 44% of ventral cores showing one or two removals (Fig.92). The few flakes bearing more than two negatives are probably predetermining CTEs struck from Levallois point cores on flakes. Faceted butts were recorded for 64.8% of all flakes and this underscores the intentionality of their removal. We can assume that the majority of Kombewa and Janus flakes were used without a further modification because 11 out of 36 specimens exhibit macroscopic use wear (Fig.94, Nr. 5-6); the amount of microscopic traces remains to be analyzed. Only one small Kombewa flake shows a retouched edge (Fig.94, Nr. 4).

6.8.7 The significance of cores on flakes in the Hummal Mousterian

The techno-typological analysis of cores on flakes in the Hummal assemblages shows that truncated-faceted pieces or *Nahr Ibrahim* types represent one part of a wider spectrum of reused blanks for flake production. A close examination of certain variables like platform frequency and configuration as well as the size and location of secondary flake scars allows for a separation of thinned tools from cores on flakes; this approach remains to be tested by use wear analysis. The cores on flakes which were identified in the Hummal assemblages mirror the importance of raw material recycling and the importance of corresponding end-products in the Mousterian technology. If the definition of cores on flakes is too restricted, a great deal of traces which reflect the flexibility of this secondary flaking method would remain unseen. The analyzed technological attributes do not reveal a conceptual difference between flakes exploited on the ventral or dorsal surface, except for the fact that the latter offers a blow-guiding scar pattern right from the beginning. Regarding the number of flakes produced on cores on flakes, the productivity gained by the recycling process seems to be low. However, if the minimal preparation effort, which in most cases only involves the creation of a faceted striking platform, is considered, the efficiency of lithic waste reuse is high. The secondary flaking process probably required a few minutes and suitable raw material was immediately at hand. The brevity of this secondary reduction process explains the relatively high number of cores on flakes compared to nodule cores.

From a technological point of view, the secondary flaking method shows two different concepts of core reduction: the Levallois concept and an opportunistic flake production. The Levallois method is reflect by certain core on flake types and the flakes struck from them. To mention first is the production of large flakes which were then taken for the removal of Levallois points on their ventral surface. This strategy is just a variant of raw material selection within the general concept of Levallois point production. Hence, they can be called “Levallois cores on flakes” according to Hovers (2007, 2009). The reduction of many dorsal cores, which actually represent the recycling of raw material, followed Levallois-like technological parameters. To mention in this respect is the exterior platform angle, platform faceting and the use of a scar pattern for controlled flake removal. Therefore, a significant proportion of secondary flakes should resemble Levallois products. Despite this technological congruence, we do not consider the core on flake method as "Levallois" for two reasons. First, the lack of surface preparation involving predetermining flakes is a basic difference between both methods. While it is true that the strategy of flaking surface exploitation visible on some dorsal cores cannot be distinguished from Levallois nodule cores, it is nevertheless an opportunistic one in the sense that it is dependent on the available scar pattern. Second, many dorsal cores show a gradual shift away from the Levallois-like exploitation strategy towards an informal flaking of remaining convexities. Many hinge and step fractures are consequences of this opportunistic exploitation.

The similarity in size between cores on flakes and exhausted nodule cores shows that the secondary flaking method was an alternative way of blank production in the final reduction stage delivering flakes within a size range of two to four centimetres on average. Blank choice was targeted but as adequate convexities and volume were the only necessary requirements, it allowed for a collection within a wide repertory including core trimming elements, retouched tools and Levallois blanks. A major problem to be resolved is the identification of secondary end-products. Apart from a few Kombewa and Janus flakes, the majority of flakes obtained in the recycling process is yet unidentified. Future analysis will focus on this problem and the possibility of refittings in order to better understand this secondary flaking technology.

6.9 Prismatic blade production

Three cores found in level 5b5 evidence a non-Levallois blade production in the final reduction stage (Fig.139, Nr.3). The blade cores exhibit a (semi)prismatic morphology and resemble small Hummalian-type specimens. Up to 6 parallel blades were struck from a plain striking platform. A few, relatively thick non-Levallois blades with a prominent central ridge can probably be correlated to this kind of prismatic blade production. Nevertheless, the insufficient sample size does not yet warrant the postulation of a distinctive technological trait (see Hovers 2009 for a similar identification problem faced in the study of ultimate core exploitation stages in the Qafzeh assemblages).

6.10 The use of limestone for flake production

The use of limestone for flake production is evidenced in several Mousterian sites of the Levant (e.g. Gilead 1980, 1988; Goren-Inbar 1988, 1998; Hovers 2009). With the exception of Farah II, their number is always very low, constituting not more than 1% of the assemblage. In this regard, Hummal is not an exception with only 7 out of 31 levels in which limestone flakes, fragments and cores were found (Tab.38). These artifacts on average account for 1.7% of the total assemblage. The travertine debris listed in Table 38 stem from locally occurring rocks, and are either fragments of hammerstones or thermoclasts. The travertine's low knapping quality precludes its use as cores. For the production of flakes a homogeneous allochthonous limestone variety was procured. Reconstructing the flaking method applied to limestone pebbles is hampered by two factors. First, the low sample size does not warrant a comprehensive reconstruction of reduction steps. Second, the limestone flakes and cores are difficult to read in the sense that the intergranular fracture results in coarse surfaces which complicate the identification of negatives and flaking directions. Moreover, most of the limestone artifacts are fragments which were probably generated during flaking. The few complete flakes suggest the application of a simple unidirectional or centripetal core reduction technique which resembles the discoid method (Fig.95). No further evidence is given by the two cores which lack any formal structure (Fig.95, Nr.3). It cannot be excluded with certainty that a certain number of these limestone artifacts are remains of splintered hammerstones. Some flakes can also represent the waste which accumulated during the fabrication of choppers and chopping tools. For the moment, the low sample size suggests that the production of limestone flakes occurred only sporadically and thus constituted an incidental element in the technological system of the Hummal Mousterian.

6.11 The typological profile: tool manufacturing

Classifying artifacts into categories or types is an important aspect of lithic analysis. However, if classification is the ultimate aim of research, then there is not much to say about the objects found in a Paleolithic site. Since the beginning of the study of prehistory, lithic artifacts have been described and catalogued, and single types or assemblages defined. The classified types or assemblages have then been correlated with chronological, functional and cultural questions. This led for example to specific tool types, such as bifaces, being used as chronological or cultural markers to define a certain time period, analogously to the *fossil directeur* approach in paleontology. Typology became the analytical method for classification, and the names chosen for single types often implicitly expressed a certain function or recognizable morphological aspect.

In the middle of the 20th century, Bordes and Laplace developed detailed typological methods to classify Lower, Middle and Upper Paleolithic artifacts (Bordes 1950, 1953a, 1953b, 1954, 1961b; Bordes & Bourgon 1951; Laplace 1964). Tools were classified according to modifications as well as by technological attributes visible on them and were then correlated with a certain function. The typological lists and the statistical analysis of *la méthode Bordes* based on the tool types became a powerful means to overcome that chaos with which a lithic analyst is faced when examining lithic assemblages. Moreover, they are a powerful means to present replicable results, and this explains why they are still widely used today.

The typological system of Bordes focused on the variability within and between assemblages, whereby single tool types and assemblage types were defined. The decisive factor is the relative frequency of tool types in a given assemblage, expressed with the help of statistical methods, namely indices. Bordes believed that the types of his typological list reflected deliberately shaped mental templates with stylistic connotations, and that ethnic groups can be traced by the typological groups named "industries". The industries were defined on the basis of excavated assemblages from a multitude of sites in Southwestern France. However, some researchers recognized that the proposed linkage between types and functions or ethnic groups is unwarranted. The most influential among them was Lewis Binford, who stirred up a controversial debate about the alleged meaning of the typological groups, which became known as the Bordes-Binford debate (Binford 1966; 1973; Bordes & de Sonneville-Bordes 1970). The effects of this debate have been felt up to the present day (e.g. Bisson 2000).

The problem inherent in the typological approach of Bordes is the subjectivity of assumptions concerning past human behavior and cognitive abilities. If the types were defined on subjective criteria, then their relevance as cultural markers must be seriously questioned.

Simply put, it was a lack of empirical evidence that troubled many lithic analysts working with the typological system.[23]

It is beyond the scope of the present study to review the ongoing debate about the analytical problems and high-level theory of typological classifications. The introductory remarks about the typological method's history are necessary, however, as in the present study the system of Bordes serves as an analytical background in the search for tool types and the patterns behind their frequency. Moreover, the widespread application of this method facilitates a comparison of the typological profile obtained for Hummal with that of other Levantine Mousterian sites (chapter 9). At the same time, the Bordes system should not be seen as a comprehensive explanation for intra- and inter-assemblage variability or homogeneity concerning the presence of tools in the Hummal Mousterian (see also Hovers 2009 for further comments about the application of Bordes' typology in recent studies).

The Hummal Mousterian displays a distinct typological profile and homogeneous distribution of tool types throughout the sequence. A major characteristic is the low proportion of retouched implements (Tab.39 and Fig.96). The highest proportion of modified flakes is found in level 5f2 at the bottom of the sequence, accounting for 23.7% of the total assemblage (excluding small chips). In general, retouched tool frequencies range between two and ten percent. The low number of retouched tools can be explained by several factors. First, it can be assumed that the majority of blanks were used without any further modification. Second, since many retouched implements can be seen as specialized extractive tools, it is possible that a certain number are lacking due to an export to task localities outside of Hummal. Third, the ubiquitous presence of flint in the El Kowm area exerted little or no pressure on the Mousterian occupants to extend the utility of their tools, as re-tooling was always possible. In other words, it seemed to have been more efficient to replace a wasted flake by producing a new one than to resharpen it. These factors are related to the more general technological

[23] In the Lower and Middle Palaeolithic, the successive emergence and disappearance of diagnostic artifacts, such as bifacially shaped tools, projectile points, scrapers, or chopping tools rather indicate a weak reflection of cultural traditions. The significance of such objects should therefore be scrutinized by taking ecological factors into account before any cultural tradition is defined. This is not to say that cultural traditions are not recognizable archaeologically, but that adequate analytical methods are needed to reconstruct them. This is a major principle in studies concerning the detection of style in lithic assemblages (e.g. Chase 1991; Close 1978; Hassan 1988; Sackett 1982). The wide distribution of certain artifacts or core technologies alone is not a sufficient argument to postulate cultural traditions and to reject functional explanations. Such reasoning is a vicious circle. Nevertheless, even in recent publications, statements like the following can be read:
"*… l'observation de traditions techniques régionales […] suggère l'existence de réseaux d'échanges culturels privilégiés impliquant des structures connues, acceptées et respectées dans la société moustérienne. La contestation de la valeur "culturelle" de telles traditions des gestes techniques est facilement réduite lorsque l'on considère l'extension de ces "faciès" à l'échelle européenne.*" (Otte 2000, 8).

organization in which the site has a certain function in relation to the settlement system (chapter 8).

It can be argued that the Levallois method allows for the production of standardized blanks which *per se* have a high utility due to a beneficial correlation of certain features, such as low cutting angle, high amount of usable edges, and a predetermined morphology. The impression that the ability to produce predetermined forms reduces the need to shape tools by retouching them can be gained by the high proportion of standardized Levallois blanks in all Mousterian levels of Hummal. However, it remains to be tested by a systematic analysis of use wear on both retouched and non-retouched artifacts in order to check for a convergence of applications. Macroscopic traces of use were found on 54% of Levallois blades, 43% of Levallois flakes, and 49% of Levallois points. It must be admitted that on some specimens, the differentiation between actual use wear and post-depositional impact is problematic. For comparison, only about 11% of cortical flakes and 13% of other core trimming elements exhibit similar traces.

The typological counts in each level are given in Table 40. The typological list of Bordes had to be modified in order to include truncated flakes, which are actually cores on flakes (type 40a) and to separate them from truncated tools, which lack any secondary removals (type 40). In addition, the original typological list has no slot for partially retouched Levallois and non-Levallois flakes, and by ascribing them to type 106 we follow the proposition of Goren-Inbar (1990). *Débordant* or plunging flakes as well as the majority of flaking surface flakes were classified as atypical Levallois flakes (type 2). Due to the low frequency of retouched implements, types 1-3 constitute the bulk of tool types in all levels. The consequences are relatively high typological Levallois indices (ILty) and low scraper and group indices (IR, Group II, III, IV, IV enlarged) based on the real counts (Tab.41). Dominant categories within the group of retouched tools are side scrapers (type 9-29), truncated-faceted pieces (type 40a) and partially retouched flakes (type 106). Apart from truncated-faceted pieces, Upper Palaeolithic tool types (type 30-40) as well as denticulates are scarcely found. This is also reflected by relatively low real and restricted Group III and IV indices (Tab.41). Notched pieces are regularly found; however, in many assemblages they are represented by only one piece.

The low number of Upper Palaeolithic tools is partly related to the fact that a considerable amount of burin-like artifacts are actually cores on flakes and were therefore not classified as tools. However, this has only slight influence on the Group III index, as the majority of cores on flakes are assigned to type 40a and thus included in its calculation. Pseudo-Levallois points and naturally backed knives are core trimming products that are nonetheless treated as tools in Bordes' typological list (types 5 and 38). In a technological sense, the Pseudo-Levallois points are flaking surface flakes that exhibit a convergent scar pattern and offset flaking axis. It is likely that the naturally backed knives are related to the early stage of Levallois point production (chapter 6.6). Given that the production of Levallois points played an important role in the majority of core reduction sequences, the regular occurrence of type 5 and 38 is not surprising.

6.11.1 Blank choice

The majority of retouched implements were manufactured on Levallois blanks (Fig.97). In most cases, the proportion of Levallois flakes and points within the group of retouched tools ranges between 70% and 100%. Their predominance cross-cuts all typological categories except for the notched pieces, of which 60% were made on core trimming elements. The focus on Levallois products is especially pronounced among the group of double-side scrapers and Mousterian points, which were almost exclusively fabricated on these blanks (94%). Core trimming elements seem to have been preferentially taken for the production of Upper Paleolithic tool types (n=5; 38.5%), notched pieces (n=8; 53.3%) and the few miscellaneous types (n=3; 75%). However, the scarcity of these types does not warrant the postulation of a significant relationship between a certain blank type and these tools. The Levallois blanks, which constitute the majority of edge-retouched tools, exhibit either no or only minimal cortex cover comprising less than 10% of the blank surface (Fig.98). This aspect further confines the sample of blanks which were preferentially modified by retouch to cortex-free Levallois products. A significant relationship between the type of Levallois blank and a distinct tool category is evidenced by the predominance of blanks with a unidirectional convergent scar pattern among the partially retouched flakes, where they account for 59%.[24] Single-side scrapers were more frequently fabricated on Levallois flakes and blades (87%) than on points. Moreover, denticulates, notched pieces and Upper Palaeolithic types were never made on Levallois points. Apart from these distinct relationships, all sorts of Levallois blank types are found equally distributed over the different tool categories. The mean size of the major categories of retouched tools is given in Table 42. It can be seen that double-side scrapers and Mousterian points were shaped out of the largest flake blanks. With a mean length of 9cm, a mean width of 4.4cm and a mean thickness of 0.9cm, they are distinctly larger than the average unretouched Levallois blanks. The mean length and width values of the other tool categories range between 6-7cm and 3-4cm respectively. With these values they are close to the upper

[24] Significance tests are not possible due to the low number of essential counts in the analyzed tool sample.

quartiles of unretouched Levallois flakes and points, which suggests that, in all tool categories, edge modification is systematically found on the largest blanks.

A significant difference from unretouched blanks is the elevated thickness of modified implements, which in all categories is found to be equal or above the upper quartile of unretouched Levallois blanks. Thus, thickness seems to have been a critical variable in the choice of blanks for further modification. The LWR values do not reveal any significant differences between the retouched and unretouched debitage sample. The relatively high LWR value of 2.4 recorded for the Upper Palaeolithic tool category could indicate that the production of burins and end-scrapers required laminar blank forms. The size difference between the unmodified part of the debitage sample and the retouched tools can be illustrated by a comparison of the mean surface size between both samples (Fig.99). In every assemblage, the range and median value of retouched artifacts are clearly higher than the corresponding values of unretouched debitage; this difference in surface size is statistically significant (t-test: $t = -18.021$; $p=0.000$). It has to be noted that this size difference, which is caused by a targeted selection of the largest blanks for tool manufacturing, is actually even stronger, because the edge retouch consumed a certain amount of flint mass, and thus the length and width measurements yield lower values compared to the actual size of the original, unretouched blank.

6.11.2 Partially retouched flakes (type 106) and the Mousterian group (Group II)

Partially retouched tools exhibit a spatially restricted modification on one edge, or on both edges. The retouched section is usually not longer than one or two centimeters. A clear distinction between use wear or post-depositional damage, and intentional retouch, is problematic for a certain number of these tools. The partial retouch can be found on the dorsal or ventral surface, and the probable intention of this type of modification was a correction of the blank's irregular shape (Fig.100, Nr. 1-2, 7). The predominance of blanks with a convergent scar pattern could indicate that in many instances the aim was to further pronounce a triangular shape that had not been fully attained during the flaking process. The same intention is probably reflected in the retouched Levallois points, which exhibit a modified distal tip (Fig.100, Nr. 6).

The transition from partially retouched flakes to single-side scrapers is fluent. On the latter, retouch extends further along the edge and is on average more invasive, as can be seen by a higher retouch depth (Tab.43). Like the partially retouched flakes, the majority of single-side scrapers exhibit a modification in their right edge. The retouch was carefully executed, forming a slightly convex, concave or straight gradient (Fig.100, Nr. 3-5, 8). Double-side scrapers, convergent scrapers and Mousterian points are represented by intensively retouched specimens, which frequently exhibit one or two completely modified edges (Fig.100, Nr. 9-12, 14). On some Mousterian points the retouch extends over nearly the whole dorsal surface (Fig.100, Nr.13). The higher retouch extension is coupled with a higher retouch depth and slightly higher edge angle. A closer examination of these features can help to disclose maintained implements (chapter 8).

The Mousterian group also comprises pseudo-Levallois points; however, it has already been mentioned that in the present technological setting these artifacts represent incidental by-products of Levallois point manufacture and are therefore not to be considered as a characteristic typological element. As the side-scrapers represent the predominant formal tool types, the Mousterian of Hummal can, in a typological sense, be characterized by a relatively high restricted scraper index (IR) and restricted Group II index (Tab.41) in high density levels. The only exception is level 5b5, which reveals one of the lowest frequencies of retouched tools in general (Tab.39).

6.11.3 Denticulates, notched pieces and the Upper Paleolithic group (Group III)

The ratio of denticulates, notched pieces and Upper Palaeolithic tool types is relatively low in all levels (Tab.40 and Tab.41). Across the whole sequence, only 12 denticulates were found, accounting for only 3.4% of the restricted tool sample. The retouch on the majority of these pieces appears irregular and it cannot be excluded that it actually stems from an intensive use of these flakes or other forms of mechanical damage. In some instances, the denticulation alternates on one edge, or on both edges (Fig.101, Nr.3). Analysis of the notched pieces faced the same problem, especially when the notch is placed on an irregular, splintered edge section (Fig.1010, Nr.4). In most cases, the notches are small, having a mean depth of only 4mm (Tab.43). The smaller the notch, the more problematic is a differentiation between edge-damaged pieces and deliberately modified tools. Due to the notches’ small size, the mean edge angle is only slightly higher than that of edge-retouched tools. As notched pieces (6.5%) occur in higher numbers than denticulates in many levels, the enlarged Group IV index is often significantly higher than the “normal” Group IV index (Tab.41).

The Upper Palaeolithic tool group (Group III) mirrors the frequency of end-scrapers (type 30-31), burins (type 32-33), perforators (type 34-35), backed knives (type 36-37), and truncated flakes and blades (type 40). Backed knives are lacking in Hummal, and the single perforator which was found during profile cuts in sediment complex 5a probably represents an incidental tool production, although it can be seen as a typical specimen. Most of the burins belong to the atypical version of this type, and a differentiation from cores on flakes is problematic. The three typical versions exhibit the removal of one or two narrow burin spalls in the distal section (Fig.101, Nr.1-2). The most frequent tool types of Group III are truncated-faceted flakes and blades, many of which are actually cores on flakes with faceted striking platforms (type 40a). They are described as "dorsal cores" in chapter 6.8. Type 40 was included in the calculation of the Group III index to allow a meaningful comparison with typological profiles of other Levantine Mousterian sites, but it was not included in the frequency determination of retouched tools. The inclusion of dorsal cores as "truncated-faceted pieces" (type 40a) results in relatively high Group III indices, which are even higher than the Mousterian index in some levels (Tab.41).

6.11.4 Choppers and chopping tools

Although choppers and chopping tools are rarely found, they constitute a significant and interesting tool category. As the brittle El Kowm flint was not suited to the manufacture of these heavy-duty tools, a more coarse-grained limestone was selected for the purpose. Large slabs of this rock type were reduced by a few flake removals on a restricted part or all over their circumference. The largest piece measures 200 x 175mm and has a weight of over 2kg (Fig.102). It probably served as a core for the production of a few limestone flakes before its edges were regularized by smaller removals. A totally different artifact type is a bifacially retouched limestone tablet, which resembles a typical Middle European Micoquian artifact form, the *Keilmesser*.

6.11.5 What can the retouched tools tell us?

The Mousterian sequence of Hummal shows a remarkable homogeneity in its tool spectrum, which is dominated by partly retouched blanks and various scraper types, other tool types being extremely rare. About two-thirds of the tool sample is made up of unmodified Levallois blanks, and the low frequency of retouched tools in many assemblages does not warrant a detailed typological description of each assemblage. The typological indices which were calculated for the richest archaeological levels (Tab.41) are nevertheless considered as representative for the whole Mousterian sequence. Characteristic typological features of the Hummal Mousterian is a high typological Levallois index (ILty), the high number of Mousterian elements (IR, Group II) and a relatively high Upper Paleolithic index (Group III) when cores on flakes are included in the typological analysis.

Looking at the low retouched tool frequency in all assemblages (Fig.96), it can be inferred that the majority of blanks were directly used for different tasks without any further modification. This scarcity of retouch is associated with a low intensity of modification at Hummal. On many tools, retouch is restricted to a small part of the edge, probably with the intention to rectify an originally irregular shape. In most cases, the impact on the edge angle was marginal, as the mean angle of retouched tools is only 5° steeper than that of unretouched blanks. To some extent, these tools can be seen to represent an extension of the efficiency in tool shaping that was already gained by the Levallois method. In case a predetermined blank did not turn out as desired, its shape was slightly corrected by edge retouch, and if the unretouched Levallois blank finally lost its utility, it was resharpened. Some Mousterian points and side-scrapers evince an outstanding invasiveness of retouching (Fig.100, Nr. 13). In the sense of Dibble's scraper reduction hypothesis (Dibble 1987), they are not seen as eliberately shaped typological templates, but rather indicate several re-sharpening events.

Concerning unifacial tools, resharpening a dull tool-edge can be done by creating small overlapping removals, the actual retouch, to regain a sharp angle between the negatives produced and the unretouched surface. Extending the utilization of a tool requires several resharpening events; as a consequence, the intensity of retouch increases. This feature puts them in category of maintained tools, meaning that they had a longer use-life, were employed for a variety of tasks, and/or were used in different contexts than unmodified blanks produced and used on the spot (Bamforth 1986; Bousman 1993).

Such heavily retouched tools are frequently used as one of several indicators for advanced planning among Middle Paleolithic hominids, in the sense that they were used for specialized extractive activities in places where raw material might otherwise not be to hand (e.g. Gordon 1993; Kuhn 1992b; Shott 1989a). As such, they constitute a nice example of the *provisioning individuals* strategy defined by Kuhn (1995), referring to tools which probably belonged to the personal gear of individuals. However, the interpretation of tools and their function must always be set against the local environmental background, especially the availability of raw materials (Bamforth 1986; Kuhn 1995; Nash 1996; Rolland and Dibble 1990). The interpretation of the variable frequency of retouched tools and the presence of curated implements as factors in the technological organization at Hummal will be discussed in chapter 8.

Apart from retouched tools which achieved their final form due to resharpening or edge correction, some specimens reflect a targeted manufacture of a distinct tool form. To be mentioned in this respect are some of the burins and chopping tools. Without the help of a use-wear analysis, the function of these tools remains unknown. Yet the robustness of the pebble tools makes it highly likely that they were used for extraction tasks with dense and tough materials, such as long bones of large herbivores or certain plant species (see also Boëda et al. 1998, 248).

6.12 Conclusion: the techno-typological features of the Hummal Mousterian and the identification of Mousterian industries

Throughout the Mousterian sequence of Hummal, some invariant technological features are discernible, particularly the exclusive use of the Levallois method during the main parts of the reduction sequence. Consequently, high IL (Levallois Index) values are recorded for all assemblages (Tab.14). In the final stage of core reduction, low core volumes frequently forced the knappers to adopt an alternative flaking method, which is evidenced by small, exhausted flake cores. From these, diminutive flakes and bladelets were struck in an opportunistic way. Identification of these small non-Levallois blanks poses enormous difficulties for the analyst (e.g. Dibble 2006), and consequently low numbers of non-Levallois blanks are recorded (Tab.14). In most levels, the number of flake cores exceeds the number of Levallois cores (Tab.15), sometimes by a considerable margin, and it is assumed that the latter were often transformed into the former at the end of their use life. Not only were Levallois cores transformed, but many flakes and retouched tools and fragments were also recycled into cores on flakes. In fact, this secondary reduction strategy occurred to such an extent (Tab.15) that we can speak of a distinct behavioral pattern in the Hummal Mousterian. Typical specimens are illustrated in Figure 86. Their frequency is probably related to the raw material import strategy, in that only a few nodule cores were brought to the site for further reduction. Also, deliberate production of small blanks and possibly a strategy of raw material conservation may be implicated in the frequency of recycled objects.

Blank production on flakes was done in various ways. In some cases, flake fragments were re-worked into Levallois cores, which makes them barely distinguishable from “normal” Levallois cores. In these and all other cases, blank production was applied either to the dorsal or to the ventral surface, or sometimes to both. Depending on which surface was exploited, we propose a classification of cores on flakes into dorsal, ventral and multiple cores. Among ventral cores, Kombewa and Janus core types are found; others underwent further reduction. One difficult-to-recognize core type on flakes is the dorsal core exhibiting one to three flake removals. Former breaking surfaces often served as striking platforms which were faceted or left unprepared when the surface angles seemed appropriate. These pieces are often described as “truncate-faceted pieces” or “Nahr Ibrahim tools”.

Despite inter-assemblage differences in blank morphology, the Hummal Mousterian can roughly be described as a laminar variant of Levallois Mousterian. This was noted by the first investigators of the site (Copeland 1985; Hours 1982), and is demonstrated by mean length-width ratios (LWR) around 2.0 (Tab.18 and Tab.22). The blade index (Ilam) does not adequately reflect overall elongation, as only true blades are used for its calculation, whereas many kinds of blanks are elongated. There is no linear trend in LWR means for Levallois blanks across the Hummal sequence, with every section displaying levels with a value over 2.0 (Tab.18 and Tab.22). In contrast, the relative thickness (RT) values display a significant inter-assemblage variability. This reflects a changing focus between the lineal and recurrent Levallois method, as well as a different use of different core volumes. The lower part of the sequence stands out clearly by exhibiting the largest and thickest end-products. Considering both LWR and RT values together, it becomes clear that in most assemblages, elongation of blanks is coupled with increased thickness (Fig.65 and Fig.66), whereas levels 5b7 and 5E are characterized by long but also thin blanks.

Working with the Levallois method requires certain preparatry steps during core reduction. In all assemblages, a systematic faceting of striking platforms is observable (Tab.23 and Tab.24). This platform shaping is necessary to cope with the flints’ fragility and to control for desired features like geometric form, low cutting angles, and regular working edges on resulting blanks. As they were mainly produced by the use of the recurrent Levallois method, assemblages showing on-site production reveal typical features of this method (Tab.26). Among the core trimming flakes, *débordant* elements such as backed knives and core edge flakes, small and thick flakes stemming from platform preparation, and plunging or twisted blades are typical by-products of the recurrent production of Levallois blanks.

6.12.1 Identifying technological traditions in the Hummal Mousterian

Apart from these common technological aspects, analysis of core reduction concepts, blank size and morphology allowed us to identify two different industries, which we have called Hummal Mousterian Industry A (HM-A) and Hummal Mousterian Industry B (HM-B). The former occurs in the upper two-thirds of the sequence and can be subdivided into two variants, HM-A1 and HM-A2. The association of single levels to these industrial facies is given in Table 44 and Figure 13. The upper two industries are characterized by the exclusive use of Levallois cores, which were exploited using one striking platform. Levallois blanks were mainly produced in a convergent or parallel fashion. The lower industry, HM-B, displays a range of Levallois flaking concepts, resulting in unidirectional, bidirectional or centripetal scar patterns. Consequently, the size and morphology of its end-products are more varied than those of the upper industry.

6.12.2 Variability in Levallois blank size

A statistical comparison between HM-A1, HM-A2 and HM-B regarding the metrics of the Levallois blanks is given in Table 45. Despite a certain inter-assemblage variability, HM-A1 and HM-A2 are very close as regards Levallois blank size. The Levallois points in HM-A2 are of the same thickness as their counterparts in HM-A1 but are a little smaller; however, this difference is not significant. The same is true of the Levallois flakes, but this time the blanks in HM-A2 are significantly thicker than those in HM-A2 (Fig.67). The strongest variability is visible in the blanks with an LWR ratio above 2.0. The upper size range of Levallois blades in HM-A1 is significantly higher than it is in HM-A2; hence, it is the presence of larger blades in the uppermost Mousterian levels that represents the most significant metric difference between the two industrial sub-types of HM-A. Furthermore, HM-A1 displays the strongest standardization in blank size – its coefficients of variation (CV) of length and width are both lower than those of the other industries (Tab.45). This is probably caused by several factors, including the strict application of one reduction concept; stronger limits in the choice of artifacts to be integrated in the transportable tool kit; and a lower degree of late stage on-site production, which produces small blanks. In contrast, blank sizes in HM-A2 display significant variability. For example, a comparison of Levallois blanks between the adjacent levels 5a2 and 5a3 reveals that the former are on average considerably smaller than the latter, especially the flakes ($t = -2.23$; $p = 0.03$; Tab.22).

By far the smallest Levallois blanks are found in level 5b5, distinguishing it clearly from the over- and underlying levels (Tab.18 and Tab.22). Furthermore, in some layers, examination of length median values shows that they are significantly lower than the mean values, which commonly fall into the range of 5 to 6 cm. These deviations reflect the presence of many small points, flakes, and blades in these levels, whereas in other levels this is not the case and both values are comparable. In contrast, small blanks with a size below 4cm are lacking in HM-A1 and HM-B. Table 45 shows that the lower HM-B industry stands out because of its larger end-products. A student’s T-test which compares the mean size of Levallois blanks in HM-A and HM-B shows that the difference in length, width, thickness, and relative thickness (RT) is significant. The only feature which is shared by all three industries is the marked elongation of the Levallois end-products.

6.12.3 Upper Mousterian industries HM-A1 and HM-A2

The HM-A1 industry is found in the uppermost Mousterian deposits, in levels 5AI to 5AVI in the southern part of the well (Fig.13). During these latest Mousterian occupations, the focus was on recurrent production of Levallois points. The ostensible preponderance of flakes and omnipresence of blades (Tab.14) is diminished by the fact that many of them are in a technological sense by-products of Levallois point production. This supposition has been corroborated by refitting studies in other point-dominated Mousterian assemblages resembling the present material (Demidenko and Usik 1995, 2003). The significance of Levallois point production can be assessed by several parameters which have been outlined above in chapter 6.5.1. If all blanks which exhibit a convergent scar pattern are taken into account, the importance of Levallois point production becomes apparent (Tab.20). An examination of cores does not give much information, as Levallois cores are extremely rare (Tab.16). However, the few examples identified indicate point removals just before discard (Fig.59, Nr.4). The scars on many blanks show a range of orientations towards the centre of the flaking surface (e.g. Fig.146, Nr.5, 6, 9, 10; Fig.147, Nr.4, 6, 7). The angles demonstrate that during reduction, striking platforms often expanded to the lateral sides of the core to allow converging or even perpendicular removals, which often occur in combination with strongly bent dorsal planes forming a prominent central ridge. Together with the pronounced longitudinal curvature of many flakes, it can be inferred that cores had slightly domed flaking surfaces. Within one reduction sequence, preferential and recurrent Levallois points were produced on the same core, whereby large preferential pieces were frequently struck at the end of a recurrent series. Blanks produced in the described manner generally exhibit pointed distal tips, a broad and thick base, and a butt with the so-called *chapeau de gendarme* shape (Tab.23). These morphological features can be regarded as characteristic for HM-A1. Over half of the points were obtained after creating more than three converging scars on the flaking surface. These “constructed” Levallois points are another distinctive element to be found in the uppermost Mousterian levels. Along with elongated specimens, a considerable portion of short points were found (Fig.147, Nr.3, 8).

The HM-A2 industry covers 17 archaeological levels with differing artifact densities (Tab.44). As will be shown in chapter 8, a significant portion of blanks were produced outside of Hummal, and thus the reconstruction of reduction strategies must rely considerably on blank attributes and the few Levallois cores found. The cores show that reduction mainly followed the unidirectional-parallel pattern also followed by the convergent flaking concept, which later became so dominant. Yet a significant level of inter-assemblage variability of scar patterns exists ($x^2 = 64.45$; $p = 0.002$), with some levels (e.g. 5b1, 5BII, and 5b5) exhibiting a clear dominance of the unidirectional pattern, whereas others demonstrate various strategies including perpendicular, bidirectional or semi-centripetal patterns (Fig.60). Inter-assemblage variability also exists with respect to relative proportions of Levallois blades, flakes and points. No linear trend towards one preferred blank type is discernible across the sequence (Tab.14). Between the lowest level, 5E, and uppermost level, 5a2, blade percentages range between 30% and 50%. The disparity between Levallois blade and flake proportions is minimal, and may in many cases be due to sample size error. Levallois points generally comprise 20% to 30% of all blanks, except for levels 5b1 and 5b5 where they are rare or even absent. Even when all blanks with a convergent scar pattern are considered, the frequency of these point-related blanks is lower on average compared to HM-A1 (Tab.20). Thus, the HM-A2 industry can be characterized by a laminar tendency, which is further underlined by the fact that the majority of flakes and points exhibit LWR means above 1.5. Levallois blades and flakes are mainly polygonal or rectangular in shape, with parallel or diverging edges. The proximal part is often narrow, with butt lengths ranging between 2 and 2.5cm for blades and up to 3cm for flakes (Tab.24). A considerable variability in point morphology characterizes the HM-A2 industry (Fig.71). In some levels, narrow, “leaf-shaped” specimens predominate, whereas others are characterized by many broad-based types. This is probably a reflection of a changing frequency in the application of the lineal vs. recurrent method, and of core volume.

In both industry types, on average 20% of Levallois blanks exhibit edge modification, whereas only around 4% of CTEs were chosen for that purpose. Due to small sample sizes, differences in tool counts between levels are not to be regarded as significant, and in fact no major discrepancies exist (Tab.40 and Tab.41). The most common retouched tools are partially retouched pieces, simple side-scrapers, and double side-scraper types, including convergent types and Mousterian points (Fig.100). The latter are represented by beautiful specimens displaying a perfect symmetry that was achieved through continuous retouching (e.g. Fig.134, Nr.4, 5; Fig.137, Nr.7, 8; Fig.140, Nr.7; Fig.150, Nr.7). Noteworthy is the frequency of ventrally retouched pieces in HM-A1, setting it apart from the underlying industries. Ventral retouch may occur along one or both edges or may be confined to the distal end (Fig.146, Nr.10-11). Other tool types are rare and in many cases appear in an atypical form. Some notches, denticulates, and Upper Paleolithic tool types occur, the latter being mainly comprised of atypical end-scrapers, as well as burins. A completely different tool group comprises two choppers and three chopping tools found in levels 5a2, 5a3, and 5b2, all fabricated from huge limestone blocks.

6.12.4 The Lower Mousterian industry HM-B

Technological analysis of the lowest Mousterian levels is limited by small sample sizes (Tab.9). Scar pattern analysis reveals that a bidirectional flaking method working with two opposed striking platforms was frequently applied to obtain huge Levallois blades and elongated flakes (Tab.19 and Fig.145, Nr.1, 4, 9), but unidirectional flaking also seems to have been applied to make similar blanks. To produce broad and long Levallois flakes like the ones illustrated (Fig.145, Nr. 6-7), the Mousterian knappers prepared huge cores in a centripetal fashion, and detached one single end-product before re-preparing the surface. Thus, investment in core trimming was often intense. Further evidence of this investment comes from two Levallois cores found in level 5e. One of them is illustrated (Fig.145, Nr.2). These specimens show that the lineal method was applied throughout the reduction sequence until exhaustion of the cores, and was probably confined to Levallois flake production. This aspect clearly distinguishes HM-B from above-lying variants, where recurrent blank production dominates. As Table 14 shows, most end-products are Levallois blades and flakes, whereas the points did not play a significant role in the tool kits' repertoire, as they did during later Mousterian occupations.

Despite small sample sizes, it seems that at least in some layers slightly more blanks underwent edge modification than in the upper industries (Fig.96). On some specimens, discrete retouch is coupled with use wear traces and can thus be interpreted as re-sharpening or re-creation of a desired edge-shape after use (Fig.145, Nr.9). On others, modification is intense, as is evidenced by some double or convergent scrapers (Fig.145, Nr.8). A definitive characterization of the tool spectrum is not possible because of sample sizes, but the range and frequencies of tool forms resemble the more recent layers, with the preponderance of side-scrapers and lightly retouched blanks (Tab.40).

6.12.5 Some words on the internal succession and chronology of the Hummal Mousterian industries

Stratigraphical observations suggest that at least some assemblages of HM-A1 correlate with the most recently deposited *in situ* layers (sediment complex S-V1) in Hummal (chapter 4.5). Techno-typological analysis indicates that despite similar production trajectories in HM-A, core reduction in HM-A1 was executed in a different style compared to assemblages which belong to HM-A2. Thus, in the present state of research, it can be assumed that HM-A1 represents the youngest industrial facies of the Hummal Mousterian. The following HM-A2 industry covers the upper Pleistocene sequence in the western sections and the middle part in the western and southern section. Although level 5a1 is not *in situ* and probably represents a palimpsest of several occupations, it is the only level of the western sequence that can be tentatively allocated to the HM-A1 industry owing to the presence of large, broad-based points (Fig.131, Nr. 1, 2, 4). The HM-B industry is found only in the lowest levels of the western section in sediment complexes V4, V5, and V6 (Fig.13). These are separated from the rest of the sequence by a colluvial deposit at the base of complex V3, which represents an erosional gap. Another massive colluvium separates the HM-B industry from underlying Hummalian levels in sediment complex 6. The base of the southern Mousterian sequence is represented by a succession of clay and palustrine carbonate deposits (chapter 4.5). A very few, intensively edge-damaged and patinated artifacts, which are non-diagnostic in terms of a techno-typological classification, were discovered in corresponding archaeological levels 5FI to 5FVII. In 2009, a Hummalian (complex S-VI) deposit appeared directly below level 5FVII (Fig.24 and Fig.25). Although a micromorphological investigation has not yet been done and we do not know whether depositional *hiati* exist, it is nevertheless fairly likely that complex 5F and S-VI represent a transition between the Hummalian and Mousterian which is geologically *in situ*. Unfortunately, the low artifact densities and poor conservation of archaeological complex 5F prohibits any technological characterization of the transition between these two Middle Paleolithic cultures.

7 The raw material situation in El Kowm and Paleolithic procurement strategies

The abundance of raw material outcrops delivering high-quality flint is certainly one of the triggering factors standing behind the density of Paleolithic sites in the area of El Kowm. Next to water, game and plants, unhindered access to a large mass of lithic material explains the prolonged presence of humans in the central part of Syria. Albeit we do not know whether there were periods of time during which access to primary outcrops was blocked, the wealth of lithic remains in stratified and surface sites and the evidence for a continuous presence of humans allows us to assume favorable conditions for raw material provisioning in all periods.

Flint outcrops are abundant (though of varying amounts and quality) alongside the Djebel Bishri formation to the north and east of the area and the Djebel Mqebra and Djebel Minshar formations to the south (Le Tensorer & Jagher 2001; Fig.103). Two main flint varieties occur in primary context: Lower Eocene and Cretaceous flint. The former can be found in the upper Paleogene layers of the Jebel Al Bishri escarpment, where it weathers out in the form of nodules (Fig.104). The Cretaceous flint occurs as lenses or bands in the Campanian beds of the Mqebra formation to the south of El Kowm (Fig.105). The location and potential of primary and secondary raw material outcrops, as well as the flint-related sites, were investigated by R. Jagher in 1990. Subsequent mineralogical-petrological analysis identified four types of Lower Eocene flint according to provenience and macroscopic features, like color and cortex type (Diethelm 1995). However, a clear differentiation between the types is problematic, and a study of thin sections revealed that the microfossil record is virtually the same in all sampled varieties. Therefore, an exact attribution of lithic artifacts found in a site to specific raw material procurement localities is impossible.

For evaluating the potential of refitting, all artifacts found in Mousterian level 5a3 were sorted into minimal analytical nodules, as proposed by Larson & Ingbar (1989). For this purpose, aspects of the raw material such as color, texture and microfossils were recorded macroscopically. This led to the definition of 44 raw material units (RMU) in the assemblage. A major problem faced when working with these groups is the significant overlap between the identified RMU and differential intensities of patination and surface weathering. In addition, it turned out that variability of color and texture exists within single nodules, and therefore erroneous differentiations are likely.

The high knapping quality of the Lower Eocene flint is remarkable. The typical color ranges from black or dark brown to light brown or grey. Thin section analysis disclosed a high density of tertiary foraminifera (Diethelm 1995, 112). Nodules found in primary context often display a chalky white cortex cover of varying thickness. Being flawless and having a homogeneous texture, this flint variety is very brittle and shows all the typical signs of conchoïdal fracture. Apart from fresh nodules in primary outcrops, displaced and weathered blocks are spread over deflation surfaces and in wadis. In the vicinity of primary outcrops, weathered and fragmented blocks, as well as knapping remains, literally cover extended surfaces and are visible from a distance as "black fields". In contrast, the Cretaceous flint variety has unfavorable knapping qualities. Due to tectonic deformations, breaks pervade the tabular blocks and hamper controlled reduction. The flint nodules and slabs show no cortex, and colors range from reddish grey to white. Next to very thin lenses, voluminous bands with a homogeneous texture occur, and they were occasionally exploited for the production of flakes during the Paleolithic period.

Other potentially usable stone materials probably occurring in close distance to the site are limestones. A highly silicified variety is found at Eocene flint outcrops in the form of voluminous blocks with suitable angles. Despite its coarser texture, this material is suitable for flake production or fabrication of core tools. When found in archaeological assemblages, the limestones do seem to represent several varieties the exact origins of which are unknown. Possible procurement localities for silicified limestones are the ancient alluvial deposits found at the bottom of several wells in the vicinity of Hummal. These deposits deliver rounded limestone and flint pebbles of suitable size.

7.1 Raw material selection strategies over time

Depending on functional requirements, variable patterns of raw material procurement can be observed throughout the Paleolithic period. Yet the differences are subtle, and in all periods Lower Eocene flint was very much in demand. Middle and Upper Acheulian assemblages from Aïn Juwal, Meirah or Nadaouyieh Aïn Askar reveal a strong focus towards exploitation of this flint type for biface production (Jagher 2000; Boëda et al. 2004). Technologies based on flake and blade production show the same preference, owing to the advantageous properties of the Eocene flint variety. In the Hummal site, this tendency is clearly expressed by a preponderance of this flint variety in all Lower and Middle Paleolithic flake industries (Fig.106). A significant exploitation of Cretaceous flint nodules and limestone pebbles only occurred during the oldest occupations of the site, which left flake assemblages accompanied by a significant amount of pebble tools. These heavy-duty tools, such as choppers, chopping tools and polyhedrons, were preferentially fabricated out of limestone and Cretaceous flint pebbles. In all periods, rounded limestone pebbles were frequently used as hammerstones. Contrastingly, the need for flakes with sharp cutting edges was met by exploiting the fine-grained Eocene flint. Thus, since the beginning of human occupation, controlled flake production or the shaping of bifaces was primarily based on this raw material type.

It is possible that raw material was also procured outside the El Kowm area. However, due to the lack of a systematic petrological-mineralogical analysis, the identification of such “exotic” flints is difficult. A light grey-colored Cretaceous flint variety of unknown origin is present in low numbers, and it is possible that this variety was imported from south of the Palmyrenian mountains (Diethelm 1995, 113).

If the Mousterian levels are examined more closely, it can be seen that a uniform frequency distribution of raw material types can be found across the sequence, with a clear dominance of the Lower Eocene flint variety (Tab.30). The quality of this flint allowed the production of flat and elongated blanks by the Levallois method. Cretaceous flint with its impurities is not suitable for that purpose, although a few blanks were made of this material. It was probably procured in wadis, as can be seen by the weathered surface remains on some artifacts. Tabular blocks of silicified limestone occasionally served as anvils for the fabrication of core tools (chapter 6.11). For this purpose, the brittle flint types were of no use. In addition, a deliberate search for limestone flakes is attested by small flakes or blades. Their frequency is extremely low, and therefore a definite reconstruction of the flaking technology is impossible. However, morphological attributes of the flakes indicate a non-exhaustive core exploitation in a simple alternating fashion. Therefore, the different raw material types were used in different ways according to their mechanical properties.

7.2 Strategies of Mousterian raw material procurement

Investigation of raw material occurrences along the peripheral zone of the El Kowm area revealed an abundance of flint-related surface sites (Le Tensorer & Jagher 2001). No detailed examination of these workshop sites has since been done, but already a quick glance is enough to recognize that during all periods, core preparation and blank production took place directly on the flint outcrops. Constant deflation affecting the Lower Eocene surfaces helps in locating the relevant spots. At some of them, palimpsests with an enormous mass of reduction debris are found (Fig.107). In contrast, other find spots disclose discrete and spatially limited knapping spots. The frequent presence of palimpsests renders a chronological or cultural differentiation of many workshop sites problematic. However, the survey conducted in 1990 disclosed at least 12 flint-related Acheulean sites, 41 Mousterian sites, 1 Aurignacian site and 2 Kebarian sites (Le Tensorer & Jagher 2001, Table 1). These numbers have to be seen as a minimum, as only spots with diagnostic artifacts can be attributed to any of these periods. Moreover, a significant number of artifact scatters are no longer visible, being either destroyed or covered by massive deposits. This could explain the rather low frequency of Acheulean sites and especially the absence of Yabrudian and Hummalian sites compared to the abundance of Mousterian findings. Due to the lack of systematic excavation and analysis of the workshop sites, a technological reconstruction of the raw material reduction that took place at these localities is impossible. Nevertheless, a brief examination allows some preliminary conclusions. Typical finds are big cortical flakes and core initialization products. Cores are present in lower numbers, and blanks are especially rare. An interesting discovery at some workshop sites is small, exhausted Levallois cores intermingled with other debris. Their flaking surfaces evidence the production of Levallois flakes or points by the lineal method, just before discard. Blank production was accompanied by intensive centripetal preparation. Thus, at least for the Mousterian, we confronted two different strategies of raw material procurement. Mousterian hominids either decorticated flint nodules and prepared initial cores and blanks for export to other localities, or they carried out complete reduction sequences until core exhaustion.

A complementary form of raw material procurement was the collection of suitable cobbles in secondary contexts such as wadis. This provisioning strategy was probably not a planned activity and it seems that displaced flint cobbles were collected whenever they were encountered. Accordingly, their proportion among Mousterian assemblages is low. The distinction between a primary or secondary raw material source can only be made for artifacts that retain a cortex on their dorsal surface. Table 46 lists the frequency of all identified cortex types in the Mousterian of Hummal. Raw material collected in secondary contexts is represented by pieces exhibiting a weathered cortex or neocortex (Fig.132, Nr.7). The latter is an abrasion caused by the fluviatil transport of flint cobbles. A neocortex or a weathered cortex is visible on 16.8 % of all cortex-bearing artifacts. The fact that nearly half of all cortical flakes exhibit a fresh cortex cover shows that material stemming from primary outcrops was preferentially procured. This value can probably be set even higher. A significant part of cortical flakes displays only the inner, silicified part of the cortex cover, so that any attribution to a raw material source is impossible. The same holds true for 163 specimens with a cortex remainder that are too small for determination.

8 The organization of technology during the Mousterian period at Hummal

The concept of technological organization is epistemologically connected to the evolutionary approach in archaeology. Evolutionary archaeology has emerged partly in reaction to the cultural-historical paradigm that dominated archaeological research from the time when the study of prehistory first became an academic discipline.[25] Its focus is on human behavior (Behavioral Archaeology) as the pivotal variable responsible for assemblage formation and variability. In evolutionary archaeology, ecological factors and the ways humans have adapted to variable environments serve as an explanatory framework for archaeological research (Barton & Clark 1997; Binford 1968, 2001; Clark 1991; Jochim 1979).

In practice, the concept of technological organization in Paleolithic archaeology concentrates on the factors that are responsible for the variability observed in the size and content of lithic or faunal assemblages. Site formation processes are the field of interest, and, apart from natural impacts on the archaeological record, analysis is guided by the search for behavioral patterns that may be discerned from material found at a site. It is believed that variable adaptive strategies on the part of prehistoric hunter-gatherers are responsible for the variations detectable in tool forms, lithic assemblage compositions, core reduction technologies or remains of animal body parts (Binford & Binford 1966; Binford 1973). The different shapes of bifaces, Middle Paleolithic scrapers or Upper Paleolithic burins are not seen as markers of cultural groups, traditions or chronological markers, but as remnants of past technological strategies. With his “functional argument”, Binford saw the variability in and between lithic assemblages as being the result of adaptive strategies resulting from different land-use and subsistence practices (Binford & Binford 1966; Binford 2001). His promotion of this view in opposition to the assumption that specific tool types or industries reflect particular ethnic groups (Bordes 1961b; Bordes & de Sonneville-Bordes 1970) led to the famous Bordes-Binford debate concerning the interpretation of Mousterian assemblages.

The attempt to relate the static archaeological record to the dynamic nature of human behavior required the search for new variables with which it could be adequately interpreted. Classic typological systems like that of Bordes (1953a, 1953b, 1954, 1961b) posed problems

[25] The evolutionary viewpoint stimulated the development of a new conceptual and methodological orientation of archaeology (New Archaeology, Processual Archaeology) that went not without criticism (Post-Processual Archaeology, Cognitive Archaeology).

for a behavioral interpretation of assemblages because they understood the archaeological assemblage as a reflection of static ethnic identities (Collins 1975; Kuhn 1991). According to this view, idealized forms were mental templates reflecting cultural groups, and lithic assemblages were defined by the presence or absence and quantity of certain tool types. With such a conception, variability in and between assemblages could not be adequately analyzed. In turn, an array of technological studies of various artifact forms and tool attributes convincingly demonstrated the questionable nature of typological categorization (e.g. Bisson 2000; Dibble 1987, 1995; Kuhn 1992a). Other studies concentrated on the analytical potential of lithic by-products, which are not included in typological classification systems, these being based only on end-products and retouched tools (Amick & Mauldin 1989; Henry et al. 1989; Rozen & Sullivan 1989; Sullivan & Rozen 1985). To overcome the subjectivity inherent in existing tool-type definitions and the use of single artifacts as representatives of whole assemblages or production methods, a search for objective attributes began with which lithic technologies could be better described. On the basis of experiments, it was shown how variability can be related to the complexity of reduction stages, whether perceived as stages or as a continuum. Some of these early investigations have been continually refined up to the present day; others turned out to be simplistic and were no longer pursued (e.g. Andrefsky 2007, 2008; Bradbury & Carr 1999; Shott 1994).

A generic feature of all these “non-typological” studies is the assumption that the variability observed in lithic assemblages reflects technological strategies that led to different rates of raw material consumption and of use, maintenance and discard of tools. The common goal is to measure the variability with adequate variables. Once these have been defined, it becomes possible to demonstrate how different intensities of raw material reduction or tool retouch mirror the complex interplay between human land-use patterns and resource distribution.

Ethnoarchaeological studies have contributed a great deal to understanding the influence exerted on technological organization by subsistence exploitation and land-use patterns (Bettinger 1987, 1991; Ebert 1979). In this respect, pioneering studies were made by Lewis Binford (1977, 1979, 1980, 1986, 2001). He observed modern hunter-gatherers in an attempt to decipher the link between their technological organization and its material manifestation. These studies had a stimulating effect on archaeologists studying variability in and between lithic assemblages or sites. The introduction of the concepts of “curation” and “expediency” as two opposing ways of producing, using and maintaining tools provoked an ongoing discussion about their actual meaning and applicability to the archaeological record (Binford 1973, 1979). However, owing to the illegitimacy of a direct analogy between modern-day hunter-gatherers and prehistoric humans, the search for references with which to make meaningful interpretations of archaeological remains was limited to some general decision-making processes. Based on the assumption that Paleolithic communities faced the same challenges and required comparable aids for subsistence exploitation as recent foragers, economic models were built to measure the basic variables, which are: time investment and risk (Brantingham 2007; Odell 1996a; Torrence 1983, 1989). Technology is seen as a means of problem-solving and a way of improving the cost-benefit ratio in terms of risk management and efficiency in resource exploitation. The basic ideas behind this conceptual framework were borrowed from the optimal foraging theory in hunter-gatherer research (e.g. Bettinger 1987; Bettinger et al. 2006; Winterhalder & Smith 2000).

8.1 Lithic organization

The concept of lithic technological organization focuses on the context of production, use, maintenance, and discard of tools. Andrefsky (2009, 66) offers a basic definition:

"*Lithic technological organization refers to the manner in which human toolmakers and users organize their lives and activities with regard to lithic technology*."

As Paleolithic archaeology has to do with prehistoric hunter-gatherers, interest focuses on the adaptive strategies of mobile foragers and on the manner in which these strategies influence tool production and use (Andrefsky 2009; Nelson 1991). Accordingly, crucial variables of the concept include ecological factors and the way foragers adapted their technology to different environmental settings. Basically, what is examined is the interplay between subsistence exploitation, land-use and lithic technology. In this sense, lithic technology is seen as a strategy or a means of problem solving. The notion of technological strategy is nicely defined by Nelson (1991, 88):

"*Technological strategies are not fixed "types" of behavior, so they cannot be said always to occur under specific circumstances or to have consistent formal or distributional implications. These strategies are plans that involve juggling variables of the natural and social environment, and the range of cultural options (social, political, ideological, technological). The need to acquire resources in different locations, to move around the landscape, to remain settled at a place, to transport different kinds of resources and material needs, and many other variables condition the technological strategies employed at a particular time and place*."

Viewing technology as problem-solving strategy sets corresponding studies into the domain of evolutionary ecology. This does not imply that prehistoric humans are believed to have behaved in a purely rational manner, or that environmental factors are the exclusive parameters for which to check. Evolutionary ecology rather serves as a theoretical framework in which variables are defined and tested, and significant relationships are explained (Kuhn 1995, 19). Technological strategies are not defined as mere economic decisions. Socio-cultural factors can be of equal importance in the way lithic technology is organized. However, such factors have not received the same attention as economic strategies (Wiessner 1982, 1983).

The organization of lithic technology was intrinsically connected to the land-use practices and mobility patterns of prehistoric foragers. While the availability and quality of stone raw material certainly had a significant effect on the scheduling of their activities, prehistoric mobility patterns were principally determined by the constraints of subsistence (Binford 1979; Ebert 1979; Kelly 1988; Nelson 1991; Shott 1986; Torrence 1983). Depending on the spatial dispersion and fluctuation of food resources, hunter-gatherers displayed two different kinds of settlement patterns: residential and logistical mobility (Binford 1980). Both had a different impact on the production, use, maintenance, and discard of lithic artifacts. Raw material provisioning, core reduction technologies and the complexity and maintenance of tools were largely dependent on the degree to which resource extraction tasks could be anticipated. Hence, planning depth and the risk of failure were crucial factors. Kuhn (1995) introduced the concept of technological provisioning to define the relationship between land-use patterns and lithic technology:

"Because the location and timing of requirements for technological aids, as well as the conditions needed for manufacture (free time and raw material), are determined in large part by the organization of foraging and land use, technological provisioning strategies serve as a kind of link between subsistence, land use, and technology. The aspects of lithic technology most sensitive to variation in provisioning strategies, and thus most pertinent to the relationship between technology, foraging, and land use, are those tactics that affect the immediate and potential utility of technological materials." (Kuhn 1995, 31)

The aim of lithic technological organization was to provide people with tools when the need arises. Depending on the mobility system and raw material availability, two principal tactics of tool provisioning can be distinguished that reflect the concept of "curation vs. expediency" defined by Binford (1979, 1980). Groups who practiced residential mobility tended to establish their residential sites in a strategic position in order to exploit a maximum range of resources in the immediate surrounding and beyond in case of an increasing depletion. Base camps tended to be occupied for prolonged periods and a wide range of manufacture and maintenance activities took place at these locales. In this context, the residential site would be supplied with a bulk of raw material for on-site reduction to guarantee a flexible orientation of tool production towards multiple ends (Nelson 1991; Kuhn 1995). In general, there was little need to maximize the utility of a tool, for example by resharpening it, as a stable raw material supply allowed for the immediate production of fresh implements (expediency). The energy costs of raw material transportation were less important. Contrarily, highly mobile foragers who practiced residential mobility were strongly dependent on an efficient exploitation of a specific resource in a neatly circumscribed moment. Residential camps, where maintenance and manufacture activities took place, were of short duration, and hence, the proximity to raw material sources was a significant influence on technological organization. Unlike logistically mobile groups, they could not alleviate shortages by procurement trips (which would be costly), and therefore, maximization of potential tool utility was a common strategy among them (Bamforth 1986; Kuhn 1992b; Nelson 1991; Odell 1996b; Shott 1996). The possibility for enhancing tool utility could be significantly restricted at task locations, such as hunting stations, when the exact timing was crucial for avoiding the risk of failure, and in unforeseen circumstances (e.g. in new territories). Implements that were highly reliable were the only means of overcoming this problem. But reliable tools frequently entail a high investment in design to guarantee an optimal function – for example, in hunting gear (Binford 1979; Bleed 1986; Nelson 1991; Torrence 1983, 1989).

The organizational effects exerted by the availability of and distance to raw material sources and the possibility of anticipating future requirements cut across the range of lithic organizations structured by different patterns of land-use (Hovers 2009; Kuhn 1995). Both variables determined how raw material was transported around the landscape. In this respect, curation of raw material by maximizing a tool's utility or hoarding a stock in anticipation of a shortage could be a suitable strategy in regions that were short of raw material. The same holds true in cases where the planning depth of resource exploitation was reduced (Binford 1979, Kuhn 1992b). An expedient use of raw material was possible when no search costs were involved, e.g. at sites located on or near raw material outcrops, or where the time and location of tool use was highly predictable. Another mode of lithic organization could have been opportunistic behavior in the form of raw material procurement and reduction as an immediate response to given needs (Binford 1979; Nelson 1991). This was only possible in cases where raw material was ubiquitous and its distribution overlapped with the distribution of other resources.

Depending on the location of a group within a given territory and on the fluctuations of resource availability, a complex interplay of several organizational strategies could occur. This poses an analytical challenge for the reconstruction of past behavioral patterns out of the static archaeological record. Success and the grade of fine-tuning depend on the amount of data to hand.

The purpose of the following chapter is to outline and test a model of technological organization in the Mousterian of Hummal by using the data derived from lithic analysis. It can only be seen as a first step on the way to reconstructing the settlement pattern and behavioral strategies of Middle Paleolithic humans in Hummal and the El Kowm region. The picture remains incomplete mainly because of quantitative and qualitative limitations in the available database concerning not only the lithics, but especially archaeozoological data and ecological variables. Hence, the aim is to present a test case which is able to guide future analysis and which is open for verification or falsification when more data is to hand. The chapter's first part deals with the different ways raw material was transported from outcrops to the site and the effects of import modalities on the structure of lithic assemblages. In the second part, further variables which measure the degree of raw material consumption are added to construct the actual model of technological organization. After testing the model's significance, results can be integrated into the preliminary picture of resource exploitation at Hummal and the site's environmental history during the late Middle and Upper Pleistocene.

8.2 Modeling raw material organization and consumption in the Hummal Mousterian

Once raw material is to hand, it has to be transported to the locality where it is needed. As already been mentioned in chapter 7, the knapping waste found in the vicinity of primary raw material outcrops indicates an initial reduction of flint nodules to reduce weight for improving the transportability of the raw material package. In the absence of sufficient technological data from the workshop sites, the mode of raw material logistics has to be reconstructed with the exported part of raw material that was introduced into Hummal. By trying to identify the imported material and its differentiation from artifacts produced on-site, an estimation of the amount and nature of the transported raw material packages becomes possible. An inter-assemblage comparison will show that variable modes of raw material import existed and were probably related to different site-functions and lengths of occupation-span.

8.2.1 The modalities of Mousterian raw material logistics as seen from Hummal

Binford (1979) argued that the procurement of raw material is mainly embedded in subsistence activities among foraging societies. While such a strategy may be true for hunter-gatherers relying on a logistical mobility pattern in relation to fluctuating resource availability, it certainly does not account for many observed regional patterns of assemblage composition that suggest targeted raw material procurement forays (e.g. Gould & Saggers 1985). The region of El Kowm offers such abundance and wide dispersion of raw-material sources that stable provisioning opportunities could be expected at all times. Moreover, the maximum distance between residential sites and flint outcrops is easily covered in a one-day walk. Thus, it is assumed that whenever need for raw material arose, targeted procurement trips were conducted. The ubiquitous presence of raw material keeps differences in availability from being explaining factor for assemblage variability, as it is in many other cases (e.g. Andrefsky 1994, Geneste 1989; Huet 2006; Henry 1989; Inizan et al. 1995, 27; Munday 1976).[26]

Andrefsky (1994) proposed a model relating differences in raw material availability to differences in tool form complexity. He proposed that if raw material availability and quality were low, mainly informal tools would be found at a site, whereas if raw material was scarce but of high quality, one would expect to find formal tools. Given the ideal case in which raw material is ubiquitous and of high quality, both informal and formal tools would be found. As the Hummal site meets both preconditions, the present discussion will examine whether the model's prediction is true or false.

Applying Kuhn's concept of "technological provisioning" (Kuhn 1992b, 1995) would equally suggest that highly maintained implements can be found next to expediently produced tools in circumstances where high-quality raw material is abundant and easily available. However, in the concept of technological provisioning, the availability of raw material is not the only determining factor; so are other aspects of technological organization. Planning depth in relation to raw material transport, tool production and maintenance are critical factors. Depending on the anticipation of future needs and the degree of residential mobility, different

[26] Since only high-quality flint was to hand, differences in raw material quality can be discounted. It follows that efficiency in core reduction and craftsmanship is the sole factor that influenced the return. Identifying the signature of individuals in lithic assemblages is an analytical challenge and requires adequate methods (e.g. Bar-Yosef & Van Peer 2009; Van Peer & Wurz 2006). The present analysis lacks such possibilities and errors in the manufacturing process can only be estimated by examining abandoned cores or blank fragments.

strategies of raw material provisioning could be applied. Given that resource availability, site-functions and occupation spans varied over the time, different procurement strategies should become visible. Places occupied over extended periods are likely to exhibit large amounts of manufacturing debris or palimpsests of several site-frequentations. In such cases, deciphering a distinct provisioning strategy becomes difficult. Standing in front of the long Mousterian sequence in Hummal gives the impression that the spring regularly attracted humans. Thus, it certainly was a known place in the Paleolithic landscape and was repeatedly visited. We can assume that Mousterian foragers knew about the activities they would carry out there when stocking up on raw material. According to the technological provisioning model, an abundance of raw material, a transport distance that can easily be accomplished, and a well-known task or residential locality that facilitates anticipation of technical requirements would correlate with the strategy of provisioning places with all possible forms of raw material units (whole nodules, prepared cores, blanks, tools). Do the assemblages found at Hummal mirror such a behavioral pattern? By examining their size and content, it will become clear whether the spring mound served as a residential camp continuously, or whether other possibilities of site-use have to be considered. Varying environmental settings can imply changes in site function as well as occupation intensity and hence different provisioning strategies.

The distance between the raw material source and the locality where it is needed, as well as the nature of the material itself, determine the modality of its transport. As flint is an easily reducible material with a zero-utility component at the exterior zone (cortex), the effort of processing this resource in the field is low. Thus, this effort should be worthwhile, most notably in case of significant transport distance. Swayed by optimal foraging theory, Metcalfe & Barlow (1992) proposed an elegant mathematical model to calculate the trade-off between field-processing a resource and transporting it under differing circumstances. Processing a resource in the field requires time and energy that could otherwise be devoted to alternative tasks. In contrast, transporting an unprocessed resource can negatively impinge on transport capacity and hence net return.

Metcalfe & Barlow’s trade-off calculation requires many parameters that are not to hand for many if not all Paleolithic sites (the number of individuals, sexual division of labor, climate, time of day, etc.). Nevertheless, the model does show that, depending on the transport distance, a threshold exists beyond which field processing became useful, and that it should be recognizable by the presence or absence of specific waste products in a given assemblage. Under the premise of a regular consumption rate, it can be assumed that the further the site is located from a raw material source, the lesser the proportion of this material should be in that locality. Regional case studies suggest that a distance-decay model can effectively describe the impact of transport distance on the structure of lithic assemblages (e.g. Andrefsky 1994; Henry 1989; Newman 1994; but see Brantingham 2003).

As Hummal is not directly located at a raw material source, flint had to be transported to the spring. The distance to the nearest primary flint outcrops is about 10 to 15km (Fig.103). It is assumed that a transportation of complete nodules, weighing several kilograms, is rather unlikely because of the negative effect on carrying capacity. Thus, a threshold favoring field processing exists, and it is supported by the presence of flint-related workshop sites at the outcrops. This seems to have been the case even for sites situated closer to raw material outcrops than Hummal (Boëda et al. 2001, 17; Jagher 2000).

Given the fact that economizing in raw material transport was a constantly applied strategy, it becomes important to reconstruct how raw material imports were organized. This means determining the quantity and the nature of the imported material. Given that these parameters are determinable, it is of interest whether different patterns regarding the modality of import are discernible across the sequence, and if so, which factors were responsible for these differences. First, we can predict that varying site-use patterns are related to differential needs of raw material. The continuum ranging from short-term to long-term occupation should be correlating with an increasing raw material quantity left at a site. Second, different types of lithic assemblages probably reflect differences in site-use (Binford 1979, 1980; Hovers 2009; Kuhn 1995; Munday 1976). Base camps in which a broad spectrum of activities took place are likely to hold specialized implements like hunting weapons next to manufacture and maintenance tools, such as scrapers. In task-related localities, we would expect specialized tools that were required for a certain activity. However, the picture is not that simple. Many additional factors, such as planning depth, raw material availability, mobility, and social organization can lead to a strong diversity in assemblage composition (Bamforth 1986; Kuhn 1995; Nelson 1991; Shott 1989b). For the sake of simplicity, and because some of the above-mentioned factors either did not influence assemblage variability (e.g. raw material) or were hardly testable in the present study, it is assumed that a general relationship between site-use and assemblage composition exists.

8.2.2 Choosing the right variables: how can the modality of raw material import be measured?

In order to understand the mode of Mousterian raw material logistics, the identification of and differentiation between artifacts produced on-site and off-site becomes crucial. In this respect it is helpful to run through possible transport scenarios and their archaeological implications (Fig.108). For instance, if all blanks and tools were produced outside of Hummal and later imported into the site, we would expect this strategy to be mirrored in layers which reveal no core reduction waste and only blanks and tools. In contrast, if flint material was imported into the site for the purpose of further reduction, corresponding by-products as well as blanks and tools produced on-site should be found in respective assemblages. These alternatives represent the two possibilities of technological provisioning. Nevertheless, the reality was certainly not as simple as those two scenarios would suggest. More likely, a complex interplay between both strategies has to be considered. This would be the case when one or several activities were carried out for which specialized tools as well as fresh material were needed. The fresh material could be collected either at primary outcrops or nearby in secondary contexts. A stock of fresh material can become important when maintained tools get damaged or lost or when the functional requirements are not fully known in advance. To reconstruct Mousterian raw material logistics, the archaeological material will now be examined with the help of specific variables that reflect differing intensities of off-site vs. on-site production.

8.2.3 Artifact density

The most obvious variable measuring the intensity of on-site core reduction is artifact density. The more blanks that were produced in Hummal, the more knapping waste accumulated at the site. However, two limiting aspects prevent any definitive statements relying on this variable alone. The first that must be mentioned is the palimpsest problem. The fact that some levels may comprise remains of more than one occupational event can lead to the false impression of intensive core reduction within an artifact-rich level that actually contains the remains of repeated low-scale blank production events. Second, the extent of excavation often covers only a restricted part of the actual occupation surface and thus potentially delivers an incomplete picture of the technological strategy (chapter 3.5). Keeping these limitations in mind, the density values can nevertheless be taken as a first indicator for core reduction intensity, but should be combined with further variables.[27]

The artifact density values in Tables 5 and 6 show that a significant variability is observable across the sequence with values ranging from 1 to over 2000 items per m^3. In low-density levels like 5AII, 5AV, 5AVI, 5BII, and 5e, the few artifacts found were dispersed all over the excavation surface, and none of these levels revealed small and spatially restricted clusters of knapping debris (chapter 5.1 and chapter 5.2). What does this mean for the estimation of core reduction and import intensity? Levels with small assemblages and low find

[27] Shott (1989b) provides a further, illuminating case study that warns against exclusive reliance on tool density for the reconstruction of occupation length and site functions. On the basis of observations made in !Kung San camps, it became clear that no relationship exists between occupation span, number of hunting trips, number of kills and tool frequency (Shott 1989b, Tab.2).

densities can be interpreted in different ways. They either reflect the import of tools for the accomplishment of certain tasks in the course of which some artifacts were abandoned, or they represent short-term occupations during which blanks were produced on-site. If the latter was the case, post-depositional displacement of artifacts could explain the lack of recognizable workshop areas. It is further possible that both technological strategies – the use of imported implements and on-site core reduction – were executed simultaneously. And finally, it is also possible that both strategies were applied at different moments but the resulting traces are found as a palimpsest. Without clear evidence to hand, the two latter possibilities can hardly be differentiated. Provided that no signs for post-depositional disturbance are detectable, the significance of low-density assemblages in terms of site-use can only be tested by examining their technological structure, as will be done below.

In contrast to these low-density assemblages, most levels revealed densities between 100 and 500 objects per m^3 next to exceptionally rich levels like 5a2 and 5a4. Two kinds of archaeological situations are relevant for their interpretation. In some levels discrete artifact scatters appeared, sometimes more than one in the same geological layer (chapter 5.1 and chapter 5.2). They can be interpreted as remains of several core reduction sequences at a certain point in time, and levels 5a2, 5a3, 5a4, 5b3, 5b5, and 5E are seen as good examples thereof. In other levels, a more-or-less diffuse concentration appeared. These levels were either affected by small-scale post-depositional displacements of artifacts, or they represent palimpsests of several knapping events. Minor vertical artifact displacements were recorded in levels 5b1 and 5b2, while palimpsests are suspected in level 5AIV, are highly likely in levels 5e, 5f1, 5f2, and are definitely found in level 5g.

Despite the problem of palimpsests blurring the picture in some levels, it is highly likely that the broad density spectrum mirrors variable quantities of raw material import. It is now necessary to check for the correlation between different raw material provisioning strategies and the resulting structure of lithic assemblages.

8.2.4 Artifact categories and technological attributes

Although the transport of whole nodules over a long distance seems rather unlikely, this assumption needs to be tested. It is possible that the transport cost was a negligible factor when raw material was procured in secondary outcrops closer to the site. In this instance, field processing could have been of lesser advantage. To assess the composition of transported raw material packages, the quantity of and spectrum within general artifact categories like cores, core trimming elements, blanks and tools will be examined. Their relative frequency in an assemblage as well as the presence or absence of specific artifact types can inform us about the organization of raw material transport and the intensity of on-site core reduction.

The variability in volume and shape of imported raw material units is too strong to find a direct expression in the size and morphology of blanks and knapping by-products found in the site. For example, a complete flint nodule can be smaller than an already reduced core, not to mention the possible variety of imported cores alone. Moreover, trying to find a precise segregation between blanks produced off-site and on-site is illusionary. For this reason, the reconstruction of on-site vs. off-site core reduction processes cannot be done by including flake A, because it was produced in the site, and excluding flake B as it was produced off-site, and vice versa.

8.2.5 Import of raw material blocks

Complete nodules were in effect occasionally transported to Hummal. Two such specimens were found, one in level 5E, the other one in level 5e. The former consists of Eocene flint with a size of 84 x 65mm and a weight of 290g. It had been tested by 4 removals and was immediately discarded because of its thick cortex cover and the presence of diaclases. The other one is a Cretaceous flint pebble collected in alluvial deposits. It is 93 x 80mm in size with a weight of 440g. Due to the material’s bad knapping quality, the pebble was not even tested, and hence its function is unclear. Both nodules are small compared to items that can be found at primary outcrops. For this reason, they rather represent an anecdotic pick-up of flint material, probably in the vicinity of the site. The same holds true for a 110 x 92mm limestone pebble found in level 5b5. Three alternating negatives are present, but the differentiation between intentional removals or fractures is problematic. As has been mentioned, limestone can be found in secondary outcrops around Hummal, and suitable pebbles were used either for pebble tools or cores. However, due to the low number of limestone artifacts (Tab.30), the modality of limestone procurement remains uncertain. The occurrence of suitable pebbles in spring deposits around Hummal suggests that procurement posed no extra effort and probably occurred *ad hoc* when the need for heavy tools arose. Otherwise the discovery of a huge core, which presumably served as a chopping tool after flake production, is hard to explain (Fig.102).

8.2.6 Import of nodule cores

Provided that the initial stage of core reduction took place at workshop sites, as is suggested by the mass of cortical flakes there, it is highly likely that already prepared Levallois cores were imported into Hummal. The shape of nodule cores made of flint is hard to reconstruct. This is because such cores are rare in all Mousterian assemblages, and the specimens found are extremely reduced (chapter 6). For this reason, any information about the shape they had at the moment of their import is missing. It has to be considered that if prepared cores served as transportable raw material stock, they could be taken for blank removal at several localities, until they were discarded somewhere. This in turn implies that they would enter a site at different reduction stages. Unfortunately, no regional database connecting patterns of core reduction in different sites with the distance to raw material outcrops is available.[28] Given that differences in debitage-to-core ratios exist between levels, they can be the result of varying intensities of core reduction, different import volumes or core exportation. As the nodule cores were systematically worked down before discard, variability in the degree of reduction can be ruled out. Low debitage-to-core ratios may have been caused by a low yield of blanks among specimens brought to the site, resulting in an elevated discard rate for cores. Contrarily, a high ratio implies that large cores were at the occupants' disposal, with intensive reduction resulting in a considerable mass of by-products. Table 47 shows the frequency of nodule cores and debitage-to-core ratios in selected assemblages.

In some low-density levels, such as 5AIII, 5AV, 5AVI, and 5e, nodule cores are relatively frequent in relation to the flake assemblage. Frequencies range from 6.9% in level 5AVI to 16% in level 5AV. Although sample size error can be responsible for this patterning, it is nevertheless appropriate to comment on it. The nodule cores found in these levels are not bigger than their counterparts in other levels. Thus, differences in core reduction intensity are not an explaining factor. It is possible that the volume of imported cores in these levels was smaller compared to other levels, and therefore, on-site reduction resulted in fewer blanks and knapping debris. Finally, the eventuality of core exportation has to be considered. The low frequency of nodule cores in many levels could be the result of core exportation. This assumption is difficult to examine, but it can be assumed that when usable cores were taken from the site, products stemming from the final reduction stage should be underrepresented. As reduction stage correlates with size, anomalies in the lower size range should be indicative thereof. More than half of all Mousterian levels lack blanks that are smaller than 3cm, and in

[28] That we have to reckon with different flint volumes transported over the landscape is undermined by two preliminary observations made outside of Hummal. First, Mousterian artifact scatters found in the surrounding mountain ranges revealed extremely small exhausted Levallois cores. At these spots, no traces of intensive core reduction are visible. Although no further information on these surface assemblages is available, we could hypothetically ask whether these remains are the waste left by mobile task groups who produced implements during off-time using small, portable Levallois cores. Second, in the site of Nadaouyieh Aïn Askar, we found a Mousterian artifact assemblage in secondary position which consists of markedly small cores and flakes (chapter 9.2.1). Although the findings were not made *in situ*, the assemblage is homogeneous and perfectly preserved. Some of the raw material units taken to produce the Levallois blanks must have been small from the beginning.

five levels, all blanks are larger than 4cm. This could be an indication for a staggered organization of core reduction in which the final stage was not always carried out in Hummal. If assemblages with more than 50 blanks are examined for blank length, the position of the lower quartile delivers more reliable information about the presence or absence of a final core reduction stage in Hummal or core export respectively. The quartile for chosen levels 5AII, 5AIV, 5a2, 5a3, 5b3, and 5b5 is given in Table 48. It can be seen that a significant number of small blanks with a size below 4cm can only be found in assemblages 5a2 and 5b5. In these two cases, core exportation is rather unlikely. As the presence of many blanks in the smallest size range does not correlate with high ratios of nodule cores, we can assume that raw material provisioning included a few large cores which were then totally reduced on-site. In levels 5AII, 5AIV, 5a3 and 5b5 small blanks are underrepresented. This can be explained either by the importation of many large-sized blanks or by the transportation of cores from Hummal to other sites before they reached the critical threshold. In levels 5a3 and 5b3 on-site core reduction was intensive; nevertheless, 75% of all Levallois blanks are bigger than 5cm. This distribution cannot be explained solely by an overwhelming presence of imported blanks, but rather by the exportation of some cores shortly before their final reduction stage. From the upper quartiles of blank length given in Table 48, the size of imported Levallois cores can be gauged. Respective values suggest that imported Levallois cores had a size of about 8cm, except in level 5b5. This assemblage clearly stands out by having the smallest blanks. A comparison with the stratigraphically closest level 5b3 shows that this size difference is statistically significant. Given that core reduction technology is the same in all levels, this discrepancy can be explained by a difference in the size of imported cores or by lower amounts of large-sized blanks in the transported raw material package. The variance in blank length between levels is statistically significant and the variability between chosen levels can be the result of more than one factor: changing amounts of blank imports, differences in the size of imported cores, and core exportation.

8.2.7 Import of reducible flakes

An alternative strategy to the import of Levallois cores is the transportation of huge flakes obtained during the initial preparation of flint nodules. Provided that a flake has enough volume to exploit and adequate convexities, it is usable for a secondary blank production. The analysis of cores on flakes and related end-products showed that a certain number of Levallois points were produced on large flakes which were probably designed for this purpose (chapter 6.8). Due to the extensive exploitation of Levallois cores on flakes, it is difficult to determine the importance of this secondary blank production and hence the amount of imported flake blanks. Striking a few big flakes from a nodule without extensive preparation is a rapidly accomplished procedure to obtain transportable raw material units. Hence, we can assume that parallel to the importation of Levallois cores, this time and energy saving method served as a beneficial strategy of raw material provisioning.

8.2.8 Import of Levallois blanks

Importation of blanks is often deduced from the size-discrepancy between cores and blanks in a given assemblage. This seems problematic, as cores are generally reduced down to a certain threshold below which no further volume is exploitable. It is difficult to reconstruct the original core size in the context of a lithic assemblage that was produced by a complex flaking method. It can be possible with the help of successful refitting sequences or with cores that fell out of the reduction sequence at an early stage. Neither precondition is given for the Hummal material, and hence, alternative methods must be applied.

Identification of imported blanks and tools is possible by taking into consideration the logic principle of flake-size decrease in the course of core reduction. This principle offers possibilities for data interpretation using a mass analysis approach (Ahler 1989; Amick & Mauldin 1989). Blanks produced during the early phase of core reduction are larger than blanks produced during later stages. The same holds true for core trimming elements related to flaking surface preparation. Suggesting that a significant amount of blanks were imported into Hummal and that this blank proportion was later boosted by smaller blanks resulting from on-site core reduction, we should expect a marked quantitative discrepancy between by-products and blanks in the upper size range. In other words, blanks produced off-site in the early stage of core reduction are not accompanied by corresponding by-products, whereas blanks produced on-site are. To determine the amount of imported blanks, a comparison of the size-frequency distributions of blanks and CTEs is useful. Flake length is the most sensitive measure of size differences, as all assemblages are dominated by blanks with a length-width ratio above 1.0. When the size frequency distributions for blanks and CTEs in a given assemblage are plotted, the two curves can theoretically intersect at any given point, depending on the frequencies in a given range. Of interest here is the question whether an intersection and deviation of both curves occurs in the upper size range, which potentially comprises imported blanks. If the frequency of blanks is higher than that of CTEs, an importation of blanks can be assumed. An example from a single assemblage, level 5a3, is shown (Fig.109). Regarding the distribution of length values for both artifact categories, it can be seen that the distribution of sizes for CTEs is biased toward the low end of the range, producing a median value of 3cm. This is due to the presence of many small flakes stemming from platform preparation.

Contrastingly, the median value for blanks is 5.8cm. A significant discrepancy in frequency distributions exists in the upper size range, with more blanks than CTEs. Similarly discordant size distributions occur in nearly all assemblages. The stronger the discrepancy, the more likely blanks are to have been imported into Hummal, and in larger quantities. A numerical "import value" can be obtained by the area between the two diverging curves in the upper size range. In Figure 109 C(L) and B(L) represent respectively the size distribution of CTEs and of Levallois blanks in level 5a3. The point of intersection is marked by L*, and L^{max} indicates the maximum length measured. The shaded area marks the disparity in frequency of blanks and CTEs in the upper size range and is calculated as:

$$\sum_{L=L^*}^{L^{\max}} B(L) - C(L) \, .$$

A value of zero implies that no import of blanks took place. Theoretically, a maximum value of 1 can be attained as both C(L) and B(L) are empirical density functions. Results obtained for each level are listed in Table 49. In combination with the primary CTE ratio, core-to-debitage ratio, artifact density values, and further variables like tool frequency, the import value can be used as an approximation of on-site production intensity.

It can be argued that a recurrent production of Levallois blanks automatically resulted in more blanks produced along a flaking surface than intermittent preparation did. This "recurrent factor" certainly has an influence on the observed size distributions, and therefore its extent has to be determined. As we do not know the actual quantitative relationship between Levallois blanks and CTEs for each production series, an arbitrary ratio of 3:1 is included into the calculation. If values still turn out to be positive, blank import is further corroborated. The fourth column in Table 49 shows the import value corrected by the "recurrent factor". As zero or negative values are lacking throughout the sequence, it is reasonable to assume that raw material import always incorporated a certain amount of blanks and tools. Inter-assemblage variability is observable, with some levels reflecting a stronger reliance on imported blanks than others. It can be objected that sample size error is responsible for the value distribution in the sense that a huge discrepancy in size between CTE and blanks is more likely to be found in low-density levels. If this is the case, we would expect a negative correlation between artifact density and import value. Calculating the correlation coefficient in fact results in a negative relationship ($r = -0.14$; $p = 0.567$). Thus, while some influence from sample size error is possible, it is statistically insignificant, and the import measures can be used for interpretation.

To lower the influence of sample size, the import values have to be evaluated in combination with the ratio of blanks in the flaked assemblage. The blank ratio simply represents the proportion of blanks in the flake assemblage excluding cores, fragments and small debris. Respective values are given in the fifth column of Table 49. Examining the import values and blank ratios together, an interesting pattern emerges. Three types of assemblages appear:

- *Type 1*: assemblages characterized by high import values and blank ratios.
- *Type 2*: assemblages characterized by rather low import values together with high blank ratios.
- *Type 3*: assemblages characterized by low values for both variables.

Several explanations are possible for this pattern. The first assemblage type clearly represents a strong reliance on blank imports during the occupation of the spring. It can be found in high-density as well as low-density levels (Tab. 49). The combination of low import value and high blank ratios in the second assemblage type can be the result of several factors. In low density-levels like 5AVI or 5BII, it can simply be caused by sample size error. In high-density levels, it could be the result of a provisioning strategy that involved blanks which are not distinguishable from on-site produced blanks on the basis of their size. It is further possible that an initial import package of large-sized blanks became successively swamped by the remains of later on-site core reduction using large cores. The third assemblage type represents a stronger reliance on on-site core reduction in the sense that only cores were transported to Hummal.

To sum up, it can be stated that importation of blanks occurred systematically, albeit in different quantities. The actual amount of imported blanks is difficult to assess, but using the size of blanks and CTEs in a mass analysis shows that the successive Mousterian occupations at Hummal saw varying amounts of blank imports.

8.2.9 Import of retouched tools

Apart from blanks, retouched tools can be another import component. In contrast to cores or blanks, tools do not reflect the site-provisioning strategy. When tools are taken to a site, this happens for the purpose of carrying out a certain activity, which is the manufacturing of other implements or processing a resource, either anticipated or not. As already described, curated tools are the material expressions of the *provisioning individuals* strategy. The question concerning the presence or absence of curated or maintained tools is related to the more general problem concerning the measurability of curation in a lithic assemblage (Andrefsky 2009; Collins 2008; Kuhn 1992b, 1994; Nash 1996; Nelson 1991; Shott 1996). Nowadays, curation is seen as a description of the potential utility of a tool and its actual use. The more a tool gets used, the more it approaches its maximum potential use, a threshold after which utility declines. In this sense, the implements' use-life or maintenance is of crucial importance (Shott 1989a). But how can the life-span of a tool be measured in an archaeological context? Several studies, some of which refer to ethnographic data, have approached this problem by proposing size, retouch intensity and morphometric attributes as defining and measurable features of curation (e.g. Shott 1989b; 2005; Kuhn 1990, 1994; Eren et al. 2005; Hiscock & Clarkson 2005; papers in Andrefsky 2008).

For several reasons, measuring curation in the Mousterian assemblages from Hummal is an analytical challenge. First, the time-investment and lab conditions that are preconditions for the measurement of currently used reduction indices, are not given. Second, a comparison with other Mousterian sites in the El Kowm region that would allow a calibration of the measured data is not possible. Third, curation often refers to tools made of "exotic" raw material which stems from remote sources and hence was treated in a different way compared to tools made from immediately available material. In all Mousterian levels, allochthonous flint is either absent or not yet identified. Fourth, Levallois blanks seem to have *per se* a significant utility without modification and are not combined with an extensive manufacturing process, compared, for example, to bifaces. Hence, it is difficult to estimate their maximum utility, especially concerning small blanks.

Interpretation of curated assemblages becomes difficult when curation is determined on the basis of retouch intensity and frequency of retouched tools. Maintained tools can be carried to and left at a site for a special activity. Intensively retouched tools can also reflect a raw material-saving behavior during prolonged site occupations (e.g. Roth & Dibble 1998). Taking artifact density and general assemblage composition into consideration can help to differentiate between such totally different behaviors. As shown in chapter 6.11, the Hummal assemblages are characterized by low tool frequencies and the majority of retouched implements show only slight modifications. Regarding this aspect and taking the easy access to raw material into consideration, curated assemblages reflecting raw material shortcomings do not exist. This means that if maintained tools are found, they can be seen as imported tools which were repeatedly used before they entered the site or as specialized extraction tools which were fabricated for a special activity.

To differentiate between on-site produced tools and maintained imported pieces, an individual flake analysis is necessary, using attributes which most likely reflect maintained tools. The first is the extent of retouch. In this respect, retouch must extend over a considerable part of the edge(s). The second is intensity of retouch, in the sense that modified edges should exhibit several retouch events. The third attribute is retouch invasiveness. Continuous retouching increasingly consumes flake mass. The consumption rate can be determined by measuring the invasiveness of retouch on the flakes' surface and by the flake mass predictor model proposed by Dibble & Pelcin (1995; see also Davis & Shea 1998), which allows a reconstruction of the original flake volume for intensively reduced pieces.[29] Retouch invasiveness can be measured by the *Geometric Index of Reduction for Unifacial Stone Tools* (GIUR), as defined by Kuhn (1990). The combination of GIUR values with the measured retouch extension along the flakes' edge will help to single out intensively modified specimens. Notched pieces and denticulates are excluded from analysis as these tool types do not reflect resharpening events, and their modifications are rather linked to functional requirements. In the present study, those tools which exhibit at least three adjacent retouch-bearing edge sections are considered to be intensively retouched pieces (Fig.57). Respective counts are given in Table 50.

To filter out potentially maintained implements from the group of tools with three or more retouched sections, only those pieces showing two or more reduction events are considered (columns 3-5 in Table 50). Secondary retouch events are not always evident and some pieces were indeterminable in respect to this feature. It is not postulated that the resulting group of tools are definitely to be seen as curated implements, but it is nevertheless likely that they were in fact treated that way. In order to strengthen the argument, the filtered group is filtered a second time using edge angle and retouch width as variables. The mean edge angle for unmodified blanks is 34°, and 42° for retouched artifacts. Recurrently modified pieces exhibit a mean edge angle of 47°, and this value is taken as a lower limit. Retouch width averages 5 to 6mm, and thus invasive retouch is securely attested for tools with a retouch width of 10mm and more. Applying these filtering variables further reduces the group of potentially maintained tools (Fig.110). The GIUR values obtained for these tools are mostly above 0.5 and therefore corroborate the impression that a considerable mass of flint was removed. Altogether, only 17 tools can potentially be regarded as curated tools; some of these are depicted in Figure 110. They are lacking in 11 out of 20 analyzed assemblages, and in the remaining assemblages their proportion is low. Therefore, we are likely dealing with an anecdotic intrusion of maintained tools during Mousterian occupations. The focus was clearly on tools produced on the spot. Nevertheless, since the modality of raw material import is of

[29] The mass predictor model is especially apt for assemblages containing many intensively retouched tools, as is the case in some European Mousterian industries such as the Quina or Ferassie type Mousterian. As the amount of retouched implements is low in the Hummal Mousterian, there was no need to apply this model, and retouch invasiveness is determined simply by measuring the maximum length of retouch negatives. Moreover, the prediction of original flake mass for reduced pieces requires measurement of the exterior platform angle (Dibble & Pelcin 1995, 430). This measurement was not taken on retouched tools found in the Hummal assemblages due to time constraints and technical inconveniences.

interest, the mere presence of such implements demands attention. The presence of maintained tools in the majority of Mousterian levels suggests that raw material import often comprised a certain amount of retouched tools. Whether they ended up in Hummal together with nodules, cores or unretouched blanks, or whether they represent blurred traces of site frequentations during which no core reduction took place and only finished implements were required, is a question that cannot be answered in the present state of analysis.

8.2.10 Determining import modalities by the type and frequency of cortical flakes

The provenance of imported flint is determinable to some extent by cortex remains left on flakes and discarded cores. Distinguishing fresh from weathered surfaces enables a distinction between "targeted" and "opportunistic" procurement, as described in chapter 7. We are absolutely aware that the distinction between targeted vs. opportunistic procurement based on cortex condition alone represents a simplification of presumably more complex strategies followed in the past. However, the weathering state of a cortex is the only attribute that allows a broad determination of the material's origin. An examination of assemblages with more than 10 cortical items shows that 50% or more of the cortex-bearing flakes and cores have a fresh cortex (Tab.51). Therefore, it seems that a targeted exploitation of primary outcrops was the preferred strategy of raw material procurement. However, the regular presence of cortical pieces with weathered surfaces shows that secondary outcrops always served as an additional raw material source. The frequency of weathered cortical surfaces suggests that up to 30% of raw material was opportunistically collected in secondary outcrops. The exploitation of secondary sources presumably gained importance during the latest Mousterian occupations, as the relatively high proportions of related artifacts in levels 5AII, 5AIV, and 5AVI suggest. While the type of cortex is indicative of procurement strategies, its quantity bears information about the reduction stages carried out inside and outside of Hummal.

To determine the reduction stage of the imported material, the presence or absence of primary preparation flakes is indicative. They are the by-products of initial core trimming procedures, such as decortication and the initialization of striking platforms and flaking surfaces. Typical products of core initialization are first flakes and flakes with a substantial cortex cover on the dorsal surface (chapter 6.6.1 and chapter 6.6.2). If such specimens are present in an assemblage, a reduction of complete flint nodules at the site is highly likely. If they are lacking, an import of already prepared cores can be suggested. In such instances, the initial phase of core reduction took place at the workshop sites and is therefore missing in Hummal. Thus, calculating the ratio of primary preparation flakes in an assemblage allows the reconstruction of the reduction stage at which the material entered the site. As already mentioned in chapter 6, primary flakes on average comprise between 10 to 20% of the flakes assemblage (Fig.76). This observation together with the results from core analysis (see above) suggests that the import of largely decorticated Levallois cores or suitable flakes was a preferred strategy of raw material provisioning. Its significance does not covary with the degree of raw material consumption, when artifact density values are taken to assess the latter; no correlation exists between density values and the frequency of early stage products ($r = 0.03$).

8.2.11 On-site raw material procurement

Apart from raw material provisioning possibilities outside of Hummal, the bulk of waste material which can be found directly in the site constitutes an alternative source of exploitable raw material. The high number of cores on flakes in all Mousterian assemblages shows that the occupants strongly relied on this kind of secondary raw material provisioning (chapter 6.8). The reuse of flakes for the shaping of tools, which is represented by double-patinated pieces, occurred only sporadically. Among 258 analyzed tools, only 8 specimens (3.2%) exhibit a secondary retouch. Thus, most of the tools were fabricated on blanks produced shortly before. However, estimating the actual amount of tools that were fashioned out of older blanks on the basis of patination is problematic. Patina formation is a complex process depending on many factors, such as the flints' mineralogical composition, the degree of moisture and the related pH, which do not change at a constant rate through time (Bäsemann 1987). The intensity of patination on a flint artifact is not a reliable estimation of the time that has elapsed since its burial (Burroni et al. 2002). Thus, it is possible that blanks were procured from older occupation waste and remanufactured into tools without being visible as such, so that the possibility of a much higher frequency of recycled artifacts has to be reckoned with.

8.2.12 Modeling raw material procurement and import modalities

As the data presented above suggest, different modalities of raw material transport and consumption existed during the Mousterian occupations of Hummal. Nevertheless, some stable tendencies are also observable, and are probably related to constant and unhindered access to high-quality raw material located within manageable distances. In such a context, it can be assumed that there was no need to conserve material. The values measured for variables indicative of raw material logistics and the spatial organization of core reduction reveal that a significant heterogeneity is present across the Mousterian sequence of Hummal. For example, a considerable amount of blank imports is observable in different assemblage types, representing either intensive on-site core reduction or a strong reliance on off-site produced material. Early-stage flakes can occur in levels that in fact are dominated by imported material. On the other hand, nodule cores are rare in some cases where they are expected to be frequent. Several factors can be responsible for this heterogeneity of the data structure:

1) sample size error
2) observer error (e.g. a false designation of an artifact to a certain technological or typological category)
3) mixing of different levels due to post-depositional disturbances
4) slow sedimentation rates leading to palimpsests which represent an amalgamation of different raw material provisioning and consumption strategies
5) variability of past human behavior (e.g. core exportation, different ways of transporting raw material)

The first two factors are the fate of nearly every archaeological study and to a certain extent are unavoidable. Sample size error can be pivotal in the analysis of low-density levels and small sized assemblages. However, exclusion of such assemblages from analysis would mean a considerable loss of information. Small assemblages derived from low-density levels constitute meaningful analytical entities (see also Hovers 2009, 17). They presumably reflect short occupation spans combined with special strategies of tool production and use. Therefore, the discrimination between analyzable and non-analyzable assemblages in a study focusing on variable patterns of land-use and site-functions is a delicate issue. In the present analysis, unequivocal anomalies in the data structure are taken as a means to focus on variable patterns of land-use and site-functions (see also Riel-Salvatore & Barton 2004 for the use of tool frequency in relation to artifact density).

The negative influence of post-depositional disturbances cannot be excluded (chapter 5). However, the magnitude of disturbance was low in most cases, and hence the composition of assemblages was only minimally affected. Reworked or collapsed Mousterian layers were not included in this study from the outset. A more serious analytical problem is posed by palimpsests. Various levels of patination and damage to artifacts can be taken as a hint of long temporal spans of assemblage formation during which remains of several occupation events got mixed together. Mixed assemblages lack any reliable information on past human activities. The evaluation of palimpsests is complicated by the absence of clear indicators. Except for level 5g, sedimentological analysis suggests that the majority of archaeological remains were rapidly buried and one can generally reckon with rather short temporal spans during which a mixing of several site-frequentations may have occurred. This means that if such mixing actually happened, it can be assumed that the adaptive strategies reflected in lithic remains were more or less the same, provided that the environmental context did not change significantly.

Variability observable in Mousterian settlement patterns is one part of the focus of this study. The other part concerns those stable tendencies which stand behind all the different kinds of individual solutions to one and the same problem: reconciling the procurement and transport of raw material with the requirements induced by anticipated or unanticipated activities.

8.2.13 Constructing the model

The variables that were chosen to reconstruct raw material logistics and the spatial patterning of core reduction can also be taken to model the Mousterian organization of technology in Hummal. This model is based upon the assumption that activities that were performed in and around the site correlate with variable occupation spans and raw material requirements. The relevant correlations between mobility patterns, site-function and lithic organization have been outlined at the beginning of this chapter. In the present study, the concept of technological provisioning developed by Kuhn (1989, 1992b, 1995) serves as a theoretical base for the model of lithic organization at Hummal. Kuhn distinguishes between two basic strategies of raw material provisioning that intrinsically correlate with the interrelationship between raw material availability, exploitation of food resources and settlement dynamics. They can be summarized as follows:

1) *Provisioning of individuals*: this strategy is related to resource procurement and processing tasks taking place away from the residential camp. Special extractive tools are required that are fabricated in advance and are intensively maintained to extend their utility. To avoid the risk of failure, the specialized tools show a high degree of durability and versatility. The strategy of provisioning individuals can also be advantageous in the context of high mobility when tools are carried around the landscape over long periods or in case raw material is scarce. Consequently, the cost of transport is the essential currency.
2) *Provisioning of places*: this strategy is responsive to more general needs in relation to a wide range of activities. Manufacture and processing tasks taking place in residential camps lead to a high density of lithic remains that varies with the duration of stay. No constraint is posed by transport costs, and therefore, the place where raw material is needed can be sufficiently supplied. The practicability and utility of this strategy depend on the residential stability of the inhabitants and on the regularity with which

resources are obtained at the respective locales. Hence, it is advantageous for groups practicing logistical mobility and in case raw material is abundant.

The theoretical concept has now to be set into the archaeological situation at Hummal. Provisioning the site with raw material can be done in different ways, and several factors, such as the degree of residential mobility and the nature of the tasks to be performed, result in a complex intermingling of both provisioning strategies (Kuhn 1995). On the basis of observations made in Hummal, the fluctuation of spring activity had a significant influence on the local ecological setting, ranging from extended lake systems to small marshy depressions. This implies that the kind and degree of resource exploitation (water, plants, animals) varied drastically. Hence, the site probably played a number of different roles in the settlement system of Mousterian hominids in El Kowm. The depositional sequence in Hummal reflects periods of relative stability (prolonged arid periods vs. prolonged wet periods) and phases with rapidly occurring alterations (pronounced seasonality, marked water transgressions or regressions). Therefore, even when the spring was a well-known spot in the El Kowm region, it was not always possible to anticipate the local resource conditions and there were probably times when the risk of failing to obtain water or game posed a serious challenge.

Two principal cases can be envisaged for how the lithic organization responded to function of the spring. Provided that the environmental setting was securely predictable, the site could have been visited for the execution of a specific task (resource acquisition, hunting, etc.). As the activities were well known in advance (e.g. when carried out regularly in a seasonal round), the raw material needs were quantifiable prior to their execution. As efficient resource exploitation requires reliable and versatile tools, the production of which is time-consuming, we can assume that all or the majority of these tools were produced well in advance (either at the workshop sites or in a residential site) and later transported to Hummal. Hence, imported implements dominate the corresponding archaeological assemblages and only a minimal amount of core reduction waste is to be expected. In general, the quantity of lithic remains should be low.

On the other hand, it is possible that the activities and circumstances of occupation were not fully known in advance, and consequently, that tool requirements could not be totally anticipated. In such a circumstance, providing the locality with an unspecific raw material package, consisting of nodules or cores for example, was a suitable provisioning strategy. By doing so, on-site core reduction could be oriented *ad hoc* towards immediate tool requirements. Corresponding assemblages would then be then dominated by a considerable amount of knapping debris and on-site produced blanks and tools. Depending on the duration of stay, the accumulating amount of lithic remains would vary, with residential camps witnessing dense scatters of core reduction waste.

8.3 Model for Hummal

As raw material was ubiquitous and transport costs minimal, the *strategy of provisioning places* was probably a suitable means of supplying raw material, independently of the site's function. The two theoretical cases are therefore not discernible by the presence or absence of this strategy. The degree to which it was applied is informative. Providing the site with "tool making potential" (Kuhn 1995, 24) was best achieved by transporting nodules or cores from primary or secondary outcrops to the locality. Subsequent reduction of these raw material units resulted in a significant amount of knapping waste. Hence, a high degree of on-site core reduction is indicative of the *provisioning places strategy*. The proportion of some of the accompanying by-products, like cores and cortical flakes, is negatively correlated with an increase of core reduction, as their frequency is lower than that for other by-products or blanks in one reduction sequence. In addition, the amount of imported blanks and tools should be low. Conversely, high proportions of off-site produced implements are indicative of the *provisioning individuals* strategy. In both cases, the differences in the intensity of raw material provisioning are presumably coupled with varying spans of occupation and lead to variable densities of lithic remains. In other words, both cases can be reflected by low-density as well as high-density levels. The differentiation between on-site vs. off-site core reduction is therefore taken as a base for the technological organization model. It is not expected to find clear-cut expressions of both cases in the lithic assemblages; rather, the focus falls on the detection of tendencies and on how the model can explain them.

With the conceptual framework defined, the variables that were used to identify the Mousterian raw material logistics and the spatial organization of blank production can be inserted into the model. The resulting structure is illustrated in Figure 111.

The proportion of cortical flakes with a weathered surface was not included in the case definition, but was used later for their interpretation. Examination of the variables showed that their value distributions reveal a significant inter-assemblage variability. Before multivariate statistics could be applied to test the plausibility of the proposed cases, each assemblage had to be allocated to a case on the basis of its composition based on the variables mentioned earlier in this chapter (Tab.52). Due to variability in and between assemblages, not all of them were clearly attributable to a specific case, with almost every allocation showing at least one deviating variable. Allocations were insecure for levels 5AII, 5AV, and 5e, thereby cross-cutting two cases. Nevertheless, the assemblage attribution was consistently possible.

8.3.1 Cluster analysis

The sub-cases can now be seen as different clusters that should be evaluated by performing a cluster analysis (Fig.112). If the results deviate significantly from the theoretically defined clusters, the validity of the latter must be questioned. Alternatively, if the general tendencies are confirmed, the model's plausibility is corroborated.

Hierarchical cluster analysis was performed with the following variables: artifact density, blank ratio, nodule core ratio, and the ratio of primary preparation flakes. Maintained tools are extremely rare or even absent in most levels, and therefore their proportions, although informative, are not significant for the modeling of cases. Together with the proportion of weathered cortical flakes, the frequency of maintained tools will be drawn on during interpretation of the obtained clusters.

In a first step, the data were checked for possible outliers.[30] The data set passed the screening test, except for levels 5f2 and 5AVI, which were identified as outliers and subsequently excluded from further analysis. Further excluded from analysis was the palimpsest level 5g. The Ward method provided a suitable approach to measure the dissimilarity of assemblages and to obtain a meaningful clustering (Aldenderfer 1982; Baxter 1994). This method holds variability inside the clusters as low as possible. To get a satisfying accordance with the model, four clusters should appear in which assemblages are grouped according to expectations. In fact, cluster analysis results in four groupings (Fig.113).

Examination of the grouped cases shows that with the exception of level 5f1, the proposed differentiation between case 1 and 2 assemblages is corroborated. Moreover, some stable clusters of sub-cases emerge. It is interesting to note that the statistical allocation of problematic cases (more than one possible sub-case) follows exactly one of the expected possibilities shown in Figure 112. The first cluster comprises levels 5b5 and 5DV, both belonging to case 1 but different subtypes. Level 5f1 is also included, even though the model expects it to fall in case 2. The second cluster is stable, showing a strong connection between assemblages 5AIV and 5E, which are both interpreted as levels generated by the accumulation of many implements produced off-site. They are grouped together with levels 5BII and 5AII, which also belong to the second case, but with lower artifact densities. The third and largest

[30] For this purpose, the nearest neighbor method is performed using the squared Euclidean distance between assemblages. If many outliers will appear, the number of analyzable assemblages is too low to obtain meaningful patterns. The method is less adequate for actual clustering, as it tends to result in long chains in the first order of clustering (Baxter 1994).

cluster combines levels 5a2, 5a3, 5a4, 5b1, 5b2, and 5b3, for which on-site core reduction with differing intensities is attested. The fourth cluster encompasses the strongly connected levels 5AV and 5e, revealing nearly identical assemblage compositions. They were grouped together with assemblages 5AIII, and all three levels were theoretically assigned to sub-case 2a.

To check the robustness of the model, the proposed number of clusters and their statistical significance were examined. In order to strengthen the assumption that four clusters actually represent the most suitable grouping of assemblages, a plot of the difference between dissimilarity coefficients for each clustering step in reverse order is useful. If the decreasing curve shows a sharp bend at the fourth cluster, the assumption is justified. The diagram in Figure 114 shows that this is the case.

To test the statistical significance of the defined clusters, a discriminant analysis is performed on the clustering solution. This is one of several validation methods to test clustering results (Aldenderfer 1982). The three discriminant vectors obtained represent the boundaries between the four groupings and their significance expresses the validity of these boundaries. Over 80% of the variance is described by the first two vectors, which means that they account for most of the between-clusters variation (Tab.53). The boundaries are tested for statistical significance. The null-hypothesis states that no significant boundaries can be drawn and a considerable overlap exists between groupings. The Wilks' lambda values all tend to 0.0, suggesting that homogeneity inside the clusters is strong. Moreover, the values are statistically significant. Plotting the first two discriminant vectors graphically illustrates the distance between clusters. For the present analysis, this aspect is shown in figure (Fig.115). It becomes apparent that cluster 2 and 4 are the most distant assemblage groupings, whereas clusters 1 and 4 are the closest (see also Euclidean distance values in Table 53. Having proved that the clustering solution is valid and statistically significant, the obtained patterning of the data has now to be interpreted in light of the archaeological situation.

8.3.2 Cluster1: levels 5b5, 5DV, and 5f1

The discrepancy between level 5b5 and levels 5DV and 5f1 in terms of sample size is caused by unequal excavation extents (chapter 3.5). Their density, however, can be regarded as high. All three assemblages contain a significant proportion of primary preparation flakes, which are tokens of on-site core reduction. In levels 5b5 and 5DV, this is further undermined by a high proportion of nodule cores. Overall, the combining feature in all three levels is the preferential import of complete nodules or cores at an early stage of reduction that were further decorticated in the site. On-site core reduction seems to have been intensive, and at least for level 5b5 this was probably coupled with a prolonged occupation span. Among the flaked assemblage, blanks account for 30% in level 5b5, 36% in level 5DV, and 40% in level 5f1. In the latter two, some blanks were presumably imported, as is suggested by high import values. All retouched tools which were found in these levels were presumably produced during occupation, as no maintained implements are present. Setting level 5f1 apart from the rest is the fact that retouched tools account for 27% in the flaked assemblage, whereas they are rare in the other two levels (5b5: 10%; 5DV: 8%).

Cluster 2: levels 5AIV, 5E, 5AII, and 5BII

In this cluster, a close connection is shown between the two high-density levels 5E and 5AIV. Both evidence a minor degree of on-site core reduction coupled with a strong reliance on imported blanks and tools. Among the latter, maintained tools are present. Levels 5AII and 5BII reveal comparable assemblage structures; however, frequentation of the site seems to have been less intense. The linkage between the two levels is weaker than between levels 5E and 5AIV because of maintained tools being present in 5AII, whereas in level 5BII they are lacking. Frequency of on-site manufactured tools is low in all four levels, with percentages ranging from 11% to 17% among the flaked assemblages.

Cluster 3: levels 5a3, 5b2, 5a4, 5b3, 5b1, and 5a2

The largest cluster comprises assemblages which are the remains of a single strategy of raw material procurement and consumption. Complete nodules or huge cores which were not completely decorticated at workshop localities were transported to the site and intensively reduced. This explains the disproportion of nodule cores compared to the flaked assemblage: the larger the imported core, the more CTE and blanks will result per item. Nevertheless, relatively high import values indicate that raw material import always included some implements produced off-site. Maintained tools are present, and they are especially frequent in levels 5b1 and 5b2. Between 10% and 25% blanks were modified into tools.

Cluster 4: levels 5AV, 5e, and 5AIII

This is the most distant cluster. It comprises assemblages with a high proportion of nodule cores. Early-stage flakes are missing, and it can be assumed that the cores were taken to the site in an advanced stage of reduction, accompanied by many large blanks. Occupation spans were probably very short, especially in level 5AIII, which has a find density of only 6 items per m^3. During these site frequentations a need for retouched tools was given, resulting in relatively high proportions between 21% and up to 32% among the flaked assemblages. It can be assumed that, as with the importance of blank imports, a significant amount of these tools were shaped outside of Hummal.

A matching of the theoretically defined assemblage groupings with the statistically derived clustering results gives a new perspective on the technological organization (Tab.54). The proposed assemblage groupings clearly reflect two different tendencies of raw material provisioning. As expected, no clear-cut assemblage types can be identified as assemblage compositions, and sample sizes are too variable across the sequence. Nevertheless, it can be clearly shown that depending on the importance and modality of raw material import, the assemblages are differentially structured. All assemblages reflect a kind of “mixed” provisioning strategy in that cores as well as blanks were transported to the site. It is the variation in the proportion of blanks vs. cores or nodules that separates the assemblage groupings. In addition, the quantity of imports, which probably corresponds to group size and occupation length, is a discriminating factor. Raw material procurement focused either on primary or secondary outcrops, the latter becoming important when imported blanks and tools had to be supplemented with fresh material. In most instances, raw material was directly transported from outcrops to the site. An exception to this is levels 5AV, 5e and 5AIII in cluster 4, reflecting the introduction of small and significantly reduced nodule cores. This suggests a delayed import, occurring after the first part of the reduction sequence had been executed somewhere else.

The intensity of on-site core reduction depends on the quantity and volume of imported raw material units. A transport of nodules and large cores to the camp resulted in one or several long core reduction sequences. If only small and already reduced cores were imported, reduction could no longer be intensive. Reduction sequences could be long but few, if many blanks compared to cores were imported, or if import quantity was generally low. Levels grouped in clusters 1 and 3 reflect a provisioning of place with nodules and decorticated cores from primary outcrops for further reduction in the site. Consequently, on-site core reduction was intensive. In contrast, assemblages in cluster 2 show a strong reliance on imported blanks, and therefore, on-site blank production was not the principal mode of tool supply. The need for retouched tools varied and seems rather unrelated to the chosen import modality. Only levels grouped in cluster 3 are uniform, in that they reflect a minor need for tools produced on-site. Maintained implements that were presumably manufactured elsewhere and used before are equally unrelated to a specific mode of provisioning. They probably arrived as “personal gear” during the pioneering phase of occupation and later became swamped by the remains of continuing blank imports or core reduction. Level 5f2 was identified an as outlier, and it is interesting to note that this assemblage is dominated by Levallois blanks and retouched tools accounting for 88% of the whole sample. Thus, it is presumably the only level to be a distinct reflection of the *provisioning individuals* strategy.

The differential degrees of on-site blank production reflected by the clusters can be cross-validated by examining the effect this variability has on Levallois blank size (Fig.116). It is expected that assemblages which stem from multiple core reduction sequences will show a larger spectrum of differently sized blanks compared to samples dominated by imports, as the latter mirror a targeted selection of certain blank forms and sizes to be transported. A comparison between import-dominated assemblages in cluster 2 and assemblages dominated by on-site produced blanks in cluster 3 shows this tendency. The strategy to combine imported blanks with large proportions of artifacts produced on-site is represented by extended size ranges, whereas assemblages dominated by blanks produced off-site show more restricted ranges. Clusters 1 and 4 are more variable in this respect, indicating that other factors, such as core reduction technology (cluster 4) and the volume of imported cores (cluster 1), had a direct influence on blank size.

A final remark concerns the ubiquity of cores on flakes. Interestingly, the secondary production of blanks seems unrelated to any provisioning strategy, as cores on flakes are found in every Mousterian level. Thus, the recycling strategy is rather not an expression of raw material scarcity. This leads us to the question of why the raw material was so extensively exploited when its availability was not a crucial factor in lithic organization. The answer can be very simple. The repeated occupations at Hummal left behind an enormous mass of knapping waste which constituted a reliable and predictable source of flint. So why bother with a logistical effort covering a distance of 10km and more, when adequate-sized material was right to hand? There are certainly a whole bundle of reasons for the importance of raw material recycling at Hummal, ranging from practical or economical considerations to the influence of children’s play or possible normative considerations, in the sense that flint was a precious resource that was not to be wasted.

8.3.3 What do the clusters tell us?

The different raw material provisioning strategies and degrees of on-site core reduction probably correlate with varying site functions. As the environmental history of Hummal remains dark at the time of writing, we can only present some hypotheses concerning the reasons why Mousterian hominids frequented the spring. Nevertheless, a combination of the sketchy archaeozoological and sedimentological data with the patterns of lithic organization provides a preliminary glimpse of Mousterian settlement dynamics.

The large cluster comprising levels 5a2, 5a3, 5a4, 5b1, 5b2 and 5b3 represents prolonged occupation spans during which a wide repertoire of differently sized Levallois points, blades and elongated flakes were struck from imported cores and nodules. The latter were procured at primary outcrops, and we can assume that this provisioning of place reflects anticipated stays at the spring. They all occurred during short phases of water regression in the context of which the site was a marshy depression with a dense vegetation cover (chapter 4). This relationship can be seen as a hint of foraging groups frequenting the site in the search of shelter and vegetal material. At that time Hummal probably served as a residential locality within which a broad range of maintenance and manufacturing activities took place. They required a large bulk of unspecific raw material units the reduction of which could be oriented towards multipurpose tools for a variety of tasks to be performed inside and outside of Hummal. Provided that the site was regularly visited, maybe during an annual cycle, caching of raw material was probably one of several options for site provisioning. Remains of charcoal, burnt artifacts and animal bones and the presence of extended tool repertoires, including choppers and chopping tools, may be taken as indications of food processing and cooking. At the same time, specialized implements for extractive tasks, such as the hunting gear, were repaired and maintained, and the heavily retouched Mousterian points are probably traces thereof. Likely, some Levallois cores were not totally exploited and were taken as a raw material reserve on trips to task localities in the surrounding landscape.

Hummal presumably was such a locality during the formation of levels 5b5, 5DV and 5f1. Small groups arrived with blanks, retouched tools and small cores, which served for blank production as soon as imported tools lost their utility. Although the database is fragmentary (e.g. no bone preservation in level 5f1), these levels probably reflect very different site functions and environmental contexts. The archaeological remains in level 5b5 accumulated during a short regression phase. Evidence for intensive on-site blank production based on limestone and many small flint cobbles which were procured in wadis indicate the need for an extended tool kit, comprising small Levallois points, quadrangular flakes, and a few retouched tools. This observation together with the evidence of burnt bones and charcoal remains suggests that an activity comprising a complex *chaîne opératoire* or several different tasks were performed at the spring, including food processing. A fireplace, which left its traces in level 5DV, was also installed during a site frequentation. This time, the spring fed an extended lake system, and we can imagine a Mousterian task group settling at its margin. They produced large Levallois blanks that were used without further modification for the butchering of hunted prey. Although taphonomic effects blur the picture, the body part representation of camels suggests that complete carcasses were butchered at the site. After humans left the spring with transportable meat portions, carnivores appeared, to scavenge among the remaining bones.[31] Due to the bad preservation of organic remains in level 5f1, any assumption concerning past activities is premature. Sedimentological analysis suggests that the site was visited during a prolonged phase of reduced spring activity. Maybe the endorheic pond was an important place for obtaining drinking water during a major arid period.

Cluster 2, with levels 5AII, 5AIV, 5BII and 5E, testifies to prolonged occupations during which on-site production of blanks occurred sporadically. The fact that the major part of the blanks and tools was imported suggests that raw material and tool requirements were well known in advance. A provisioning strategy including a minimum amount of unspecific raw material units also implies that transport costs were a crucial currency in the technological organization. Hence, as a tentative hypothesis we assume that assemblages in cluster 2 reflect either task groups visiting Hummal for resource exploitation, or highly mobile foragers who used the spring as a residential locality. In the latter case, these groups practiced a higher mobility than their counterparts who left their traces in cluster 3 levels.

The lithic artifacts in levels 5AII and 5AIV were found in evaporitic deposits that were significantly altered by pedogenesis. It can be assumed that the spring was a shallow, sedgy depression that offered shelter, vegetal food or the possibility of being used as a hunting post. As it is unclear whether both levels represent palimpsests of several short-term frequentations and because of the lack of faunal remains, no hypothetical conclusion can be drawn from the presence of maintained tools and the abundance of Levallois points. However, the discovery of possible bitumen in association with the proximal part of a Levallois blank in level 5AII indicates that specialized tools were manufactured or repaired.

The sedimentological context of levels 5BII and 5E suggests that Mousterian hominids settled at Hummal when the spring fed an oxygen-rich lake. The lithic artifacts are accompanied by camel and horse bones in level 5BII, and remains of camels, horses, gazelles and ostriches in level 5E. Although the human impact on these faunal remains is still to be verified, findings of charcoal and burnt bones in both levels is seen as an indication for the transport of carcasses to the site for processing and meat consumption. It is fairly likely that humans settled at the spring during a certain season when a hunt for these animals had been highly productive. Perhaps migrating herds of camels, horses and gazelles were targeted at neighboring water spots where these animals gathered. The transport modality of carcasses from the kill-site can depend on the size, and hence the weight, of the hunted animal (Griggo 1998a). The discovery of horn-shafts from gazelles in level 5E could suggest that complete

[31] Direct evidence of butchery is given by cut marks identified on a long bone fragment. Gnawing traces left by carnivores were found on claviculae and skull fragments.

carcasses were transported to the site, whereas the scarcity of cranial parts and phalangae and the overrepresentation of limb portions belonging to camels indicate that these large-sized animals were disarticulated directly at a remote kill-site to improve the carrying capacity.

Levels 5AIII, 5AV and 5e are probably the remains of small task groups that carried with them a lightweight tool kit consisting mostly of Levallois cores and retouched tools. The cores were taken for the production of a few blanks at different locales. It is possible that the few unretouched Levallois points and side scrapers, together with many Levallois blank fragments and small debris found in levels 5AIII and 5AV, represent the renewal of hunting gear. Retooling, preserved in level 5e, was presumably also done during the site frequentation. The assemblage consists of equal proportions of complete and broken Levallois flakes and blades as well as two completely reduced Levallois cores.

The mentioned reconstructions concerning the variable functions the site had over several millennia suggest a complex picture of different activities, group sizes and occupation spans which are intrinsically related to the constantly changing local environment. It has to be stressed that these reconstructions are highly speculative due to the scarcity of corroborating data from archaeozoology and paleoecology. Moreover, the small window opened by the current surface excavations and test pits at Hummal certainly does not provide a comprehensive insight into the Mousterian land-use systems in the El Kowm region. Nevertheless, as we mentioned at the beginning of this chapter, the presented model of technological organization should be seen as a test case and first step on the way to a more thorough understanding of Mousterian settlement dynamics at Hummal and beyond. Despite the variability of possible site functions, a general tendency concerning the relationship between assemblage size and site milieu has been observed across the sequence. The majority of high-density levels were found in deposits that mirror periods of water regression and reduced spring activity. Contrarily, low-density levels – which presumably reflect short-term frequentations – often correlate with phases of significant freshwater input, leading to extended lake systems. Few artifacts were also found in deposits which presumably accumulated during longer dry periods, as is the case at the base of the Mousterian sequence. It can be argued that high-density levels in combination with pedogenic sediments are actually palimpsests of several occupations due to lack of rapid burial in times of decreased spring activity. While this cannot be excluded, micromorphological results and the fact that many soil formations are only poorly developed support a generally high sedimentation rate. In addition, many thin, evaporitic deposits are presumably the result of increasing evaporation restricted to one annual season. It can be further argued that the impression of short-term site frequentations in the context of extended lake systems, which are represented by massive freshwater carbonates, is a misinterpretation caused by the limited size of excavation areas. Do we fail to grasp the core area of occupation in the present state of excavation due to an extension of littoral zones in times of water transgressions? The excavation of test trenches leading away from the well center will seek to answer this question.

On the assumption that the clustered levels indeed reflect differential intensities of occupation, the water level regression-prolonged occupation vs. water level transgression-short-frequentation pattern can be illustrated by placing respective levels into the hypothetical evolution of the artesian spring system. This can be shown by using the southern sequence as an example (Fig.117). The deposits at the base (S-V5-7 to S-V5-1) represent rather long intervals between wet and dry phases, in which extremely arid conditions probably predominated. Hence, prehistoric humans mainly avoided the site and presumably the whole region of El Kowm. In later times, rapid fluctuations of the water table, provoked either by a constantly changing climate or by site-specific processes, correlate with the mentioned site-use pattern. A very simple thought can be offered for discussion: as soon as the source contained water, animals were attracted and gathered at the waterhole. In the hunt for these animals, it is unlikely that humans installed their base camp in close proximity. Contrarily, at moments when the source dried up, the depression served as an optimal place for a sheltered camp and prey was hunted at waterholes in the surrounding region. Unfortunately, a database concerning major facies that can be correlated between the deeply stratified sites in El Kowm, is not to hand. Hence, we do not know whether a specific deposit represents a water regression or transgression caused by local phenomena, such as a micro-tectonic process or climatic shifts. Knowing this would enable a more refined understanding of how humans reacted to these changing circumstances.

9 The place of Hummal in the Levantine Mousterian

Working on Middle Paleolithic variability in the Levant is a challenge for several reasons. First, such a study has to evaluate and interpret data from many sites that were first investigated by excavation methods that do not match our modern-day standards. Second, many artifact collections are dispersed over several institutions and therefore lack their internal consistency (the Tabun collection is an example). Third, only a few publications offer comprehensive raw data from which necessary and reliable information for all kinds of research questions can be drawn. Fourth, political factors and an unnecessary rivalry between different nationalities and research institutions unfortunately blocks access to sites or artifact collections for individual researchers, especially in the Levant.

It is not our aim to present a new synthesis of Levantine Mousterian variability. Surely, such an endeavor would be a challenging and exciting PhD subject on its own. The aim of the following chapter is to compare the Hummal Mousterian assemblages with other published sites that were chosen because of similar techno-typological traits, or with sites from which raw data is to hand, to enable a check for similarities as well as differences (Fig.118). Although future work with a larger sample size to hand will certainly lead to a refinement of the techno-typological aspects presented in chapters 6 and 8 of this thesis, the Mousterian sequence of Hummal already offers further data for the still fragmentary picture we possess of the Levantine Mousterian. Due to the lack of reliable radiometric dating results, the chronological positioning of the Hummal sequence can only be done on techno-typological grounds.

As it would be impossible to obtain first hand-data on all currently known Mousterian sites and museum collections within a reasonable timeframe, we had to rely largely on published reports and articles. Information concerning certain sites is often widely dispersed in the literature and the analysis of one assemblage by different persons unavoidably leads to contradictions in the published data. In the following discussion, only those assemblages for which sufficient and reliable information is available, are considered. It is important to note that the lack of analytical standards in the research on Mousterian lithic technology is a problem with which a comprehensive regional analysis cannot be reconciled (see discussion in chapter 6.2).[32]

In the course of lithic analysis and on the basis of stratigraphical observations, it became clear that the major part of the Mousterian sequence of Hummal, as it is known today, comprises a relatively late Mousterian with point-dominated assemblages. The comparison of layers 5AI to 5E with other assemblages will therefore focus on Levantine sites showing a comparable technological profile. Nevertheless, the marked elongation of Levallois points and the relatively high number of blades in many Hummal levels are also reminiscent of Early Levantine assemblages, and this explains why the lowest layer of Yabroud and Tabun unit IX are equally discussed. As we have seen, Hummal layers 5e to 5g radically distinguish themselves from the overlying sequence. Unfortunately, the insufficient sample size hampers a distinct allocation of these assemblages to any of the Levantine Mousterian complexes.

Typically, the identification of major shifts in Levantine Mousterian technology in the Tabun sequence leads to a tripartite division of this period into succeeding phases D, C, and B. Since its definition by Lorraine Copeland (1975), this 3-stage model serves as an analytical framework for inter-site comparisons (e.g. Bar-Yosef 1998; Bar-Yosef and Meignen 1992; Copeland 1981a; Jelinek 1981; Shea 2003). However, the accuracy of the phase model is

[32] To illustrate this drawback, the Levallois index (IL) can serve as an example. As defined by Bordes (1961b), this index measures the proportion of Levallois blanks among all blanks (flakes, blades, and points); core trimming elements, termed *éclats de taille* in Bordes' definition, are not included. It is a helpful means to determine the significance of the Levallois technique in assemblages which were generated by more than one flaking technology. Hence, in assemblages that represent an exclusive use of the Levallois technique, the Levallois index should tend to 100. Yet, scanning the published data for respective Levantine assemblages such as Amud (Hovers 1998), Kebara (Bar-Yosef et al. 1992; Meignen & Bar-Yosef 1991), Qafzeh (Hovers 2009), or Tor Faraj (Henry 1995), shows that the index ranges between 20 and 40. Does this imply that the Levallois method was accompanied by an alternative non-Levallois flaking concept? Looking at the technological data, the answer is simply: no. So what is taken as a denominator to arrive at such low indices? The problem is represented by the "indeterminate" group proposed by Copeland (1983b; see discussion in chapter 6,2) or the fact that only Levallois points are seen as tools (Henry 1995). Levallois core reduction produces a large number of unspecific by-products (e.g. Geneste 1985), of which the technological status is not discernible in archaeological samples; in the present study, such flakes were subsumed in the *sensu largo* group of core trimming elements. Although such pieces can serve as tool blanks, they were not the desired end-products which are represented by typical or atypical Levallois blanks. Just because they are neither clearly relatable to a distinct CTE category nor to Levallois blanks, their designation as non-Levallois blanks is misleading, because they in fact originated from Levallois cores. Nevertheless, the "indeterminate" group and alleged non-Levallois blanks are included in the IL's denominator, and consequently rather low values are obtained. But what then is actually measured by the IL? Clearly put, when there is no evidence for a true parallel non-Levallois *chaîne opératoire*, such as the prismatic blade production in the Early Levantine Mousterian, the index thus calculated measures the proportion of Levallois blanks among a selected group of CTEs. In this sense, it is meaningless and does not accord with Bordes' definition. This issue clearly needs further discussion. The IL restricted to end-products of the Hummal Mousterian is given in Table 14 and as the major bulk of these flakes were produced by the Levallois method, the values are very high, ranging between 80 and 100. For the sake of comparison, we calculated a "real IL" including the core trimming s.l. group and flaking surface flakes, although its significance can be questioned.

tenuous. Reliable results for radiometric dating of Middle Eastern sites are still sparse, and the age of the Tabun sequence itself is still debated. In addition, discovery of new assemblages and re-analysis of older collections disclose a significant variability within the proposed stages (Bar-Yosef et al. 2005; Henry 1995a, 2003; Lindly and Clark 2000; Meignen 1998a, 1998b; Monigal 2002; Munday 1979).

A significant techno-typological variability is observed among Early Mousterian assemblages from sites which have been dated in between 260 and 180ka BP (Bar-Yosef 1998, Bar-Yosef & Meignen 2001; Meignen 2007; Munday 1979). Dated key sites are Tabun unit IX, Rosh Ein Mor and Hayonim F / Lower E (Grün & Stringer 2000; Mercier et al. 1995; Mercier et al. 2007; Mercier & Valladas 2003; Rink et al. 2003, 2004); sites with chronological uncertainties but technological affinities are Hummal layers 6-7, Nahal Aqev 3, Douara IV, Jerf Ajla E-F, Yabroud KS 8-10 and Ksar Akil XXVIII (Marks & Volkman 1986; Munday 1979; Nishiaki 1989; Schroeder 1969; Solecki & Solecki 1995; Wojtczak in preparation). Several core reduction systems coexisted and inter-assemblage variability is mainly characterized by a shift between non-Levallois vs. Levallois methods (Monigal 2002). Given this variability, a precise definition of the Early Levantine Mousterian is problematic if not impossible. In the present state of research, it seems that in some sites the exploitation of prismatic cores was the principal means for blade production (e.g. Hummal, Hayonim), whereas in other sites this aim was preferentially achieved with the Levallois method (e.g. Yabroud, Tabun IX). However, there are no clear-cut differences in the technology, and the interrelationship between these reduction methods needs to be clarified.[33] A common aspect of all Early Mousterian assemblages is the abundance of blades, elongated points and Upper Paleolithic tool types. The problem is that high blade proportions and elongated points are equally found in much younger sites, which stimulates discussion as to their chronological position and the meaning of Levantine Mousterian variability in general; one such example is the site of Ain Difla, which revealed extremely elongated points and evidence for non-Levallois blade production (Clark et al. 1997; Lindly & Clark 1987). Moreover, some point-dominated Late Mousterian assemblages show a considerable overlap with Early Mousterian sites in respect to certain techno-typological features, as will be shown with reference to the Hummal Mousterian.

The younger phase or phases of the Levantine Mousterian are equally problematic in terms of defining clear-cut stage successions or a linear technological trend (Goren-Inbar & Belfer-Cohen 1998; Hovers 1998). Based on Tabun level C, Copeland (1975, 1981a) proposed

[33] Layers 6 and 7 of Hummal bear evidence for an equal importance of prismatic blade and Levallois flake production. Analysis of cores and core trimming elements shows that a technological convergence between both methods is possible (Wojtczak, personal communication 2007).

a second Mousterian phase characterized by relatively broad, oval-shaped Levallois flakes, which were removed from centripetally prepared cores, and a replacement of Upper Paleolithic tools by side scrapers. Although Copeland did not postulate a chronological ordering of her stages, she subsumed assemblages containing broad-based Levallois points within a third phase in analogy to level B at Tabun. Jelinek saw the Tabun C and B type Mousterian as different facies responding to specific environmental settings, and not as a succession of separate cultural entities (Jelinek 1992). Contemporary thought about the phylogenetic position of both Mousterian variants is inconclusive, with several researchers favoring a temporal succession of the two complexes (e.g. Bar-Yosef 1998; Bar-Yosef & Meignen 2001) and others pertaining to Jelinek's facies idea (e.g. Lindly & Clark 2000). As is the case for the earlier Mousterian phase, some Tabun C-like sites, such as Tabun unit I, Skhul B and Qafzeh, seem to cluster in a delimitable time frame of 170 to 80ka BP (Grün & Stringer 2000; Mercier & Valladas 2003; Mercier et al. 1993; Schwarcz et al. 1988; Valladas et al. 1988), whereas others, such as Quneitra, are much younger despite similar technological traits (Goren-Inbar 1990).

It is not our intention to cut the Gordian knot surrounding the question of which assemblage belongs to which Mousterian complex and whether it is reasonable to expect a coherence of technological patterns and chronometric results in the sense that different traditions follow each other in time. The confusion concerning Levantine Mousterian variability is largely a result of conflicting dating results, varying theoretical approaches and inconsistency of analytical systems. It is fairly reasonable to assume that a complex and region-specific interplay of technological traditions, subsistence strategies, mobility and land-use patterns is responsible for the apparent lack of a distinct techno-typological trajectory over time (see also Hovers 2001, 2009; Marks 1992; Munday 1976). Nevertheless, some general tendencies can be defined. The final Mousterian period is placed in the time-range of around 80 to 50 ka BP and saw an increase in point-dominated assemblages; this seems to be the case in the coastal region as well as in the arid steppe of the interior and the desert areas of the southern Levant (Hovers 2009). A characteristic feature of the Late Levantine Mousterian is the nearly exclusive use of the Levallois method and a marked standardization of the convergent flaking concept for Levallois point production. However, morphological variability among the point assemblages is stronger than is often claimed, and the Hummal assemblages clearly show that the short and broad-based point with a *chapeau de gendarme* is not the only typical specimen.

9.1 Preliminary age determinations of the Hummal Mousterian

Exacerbating uncertainties about the chronological position of the Hummal Mousterian is the fact that only preliminary dating results are available at present. Thermoluminescence (TL) dating of heated flint from levels 5b3 and 5g gives only a rough idea of the possible age of these levels. TL dating of the Middle Palaeolithic levels in Hummal is currently performed by D. Richter (Max Planck Institute for Evolutionary Anthropology, Leipzig). Dating of level 5b3 delivered a minimum age of 36 ka ± 5 ka years BP, whereas the age of lowest level 5g is placed between 98 ka ± 16 ka and 128 ka ± 18 ka years BP. These dates are far from definitive, and techno-typological features are a better means for comparing Hummal with other sites in the region and beyond.

9.2 Hummal's place in El Kowm and the interior Levant

Despite the outstanding density of Paleolithic sites in the El Kowm region, a comparison of the Hummal Mousterian sequence with neighboring sites is hampered by the fact that an adequate regional database does not exist. This all the more regrettable as the majority of stratified well sites and surface scatters contain Mousterian artifacts. This density underscores the enormous potential for future investigations. The well of Umm El Tlel, which is located a little more than 10km northeast of Hummal, is the only site with a comparable Mousterian sequence under excavation. Despite an overwhelming abundance of lithic and faunal material, primary techno-typological data concerning the whole range of the excavated assemblages are not yet available. Published results deal either with general overviews, possible site functions or extraordinary discoveries, such as bitumen for the hafting of tools, in the course of which some Mousterian assemblages are briefly described (e.g. Boëda & Muhesen 1993; Boëda et al. 1998, 2001). Thus, we can only present some general considerations concerning the technological relationship between Hummal and the Mousterian sequence of Umm El Tlel. Another spring-related locality, from which Mousterian assemblages are at our disposal, is the well-known Acheulean site of Nadaouiyeh Aïn Askar. Like Umm El Tlel, this ancient spring is located around 10km north of Hummal. Unfortunately, no *in situ* Mousterian levels have yet been found, and the available material is derived from disturbed contexts. However, the discovery of a displaced but homogeneous lithic sample in a test trench of Nadaouiyeh delivers at least another piece of the Mousterian puzzle. Shifting the scope to a wider area encompasses the stratified sites of Douara Cave, Jerf Ajla, and Yabroud.

9.2.1 Comparison with Nadaouiyeh Aïn Askar

Two Mousterian assemblages were available for a techno-typological study. The *remanié*-sample represents a surface collection and is certainly a mixture generated by the destruction of original deposits by natural and human impacts. The artifacts show different degrees of patination and damage, and the sample can therefore not be considered as representative. Moreover, the bias caused by the arbitrary selection of artifacts is clearly shown by the scarcity of cores and core trimming elements in contrast to the high number of Levallois blanks (Tab.55). Although the *remanié*-assemblage does not provide reliable information, the technological characteristics of some specimens underscore the variability a regional study of the Mousterian has to reckon with. To be mentioned are Levallois blanks with all kinds of scar pattern types which were struck from recurrently or preferentially exploited cores. Some of the Levallois points, as well as large preferential Levallois flakes showing a centripetal scar pattern, often modified into side scrapers, show an affinity to pieces of the HM-A or HM-B industry in Hummal (Fig.119).

The trench P50 sample was found in an erosive channel infilled with a massive sand deposit. Many abraded faunal remains and well-preserved lithic artifacts were unearthed from this sand. Although in secondary position, the lithic sample can be considered as homogeneous. The artifacts exhibit no abrasion or edge damage and the patination is weak throughout. In addition, the considerable amount of small debris (< 2cm) suggests that no sorting affecting the smallest-size grade occurred. Compared to the majority of the Hummal assemblages, the P50 sample reveals many core reduction by-products, especially cortical flakes and Levallois cores (Tab.47). This is an indication of an on-site operational sequence involving all steps ranging from the decortication of flint nodules to Levallois core discard. A comparison between the sites' cortical flakes, core edge flakes, cores and Levallois blanks shows that the blanks were exclusively produced at Nadaouiyeh (Fig.120 and Tab.56). The blanks' upper and lower size range matches those of the by-products and cores, and therefore, an import of large-sized blanks is rather unlikely. Although the import value of 0.43 falls into the lower range of values calculated for Hummal (Tab.57), it does not exclude blank importation. However, a correction by the recurrent factor results in a drop to -10.53 (see chapter 8.2.8 for an explanation of the import value calculation). For comparison, none of the Hummal assemblages reveals corresponding values below 0. The first stage of reduction saw a removal of cortical flakes, followed by large blades, which were struck from one or two opposing striking platforms (Fig.121). The Levallois cores were exploited in a recurrent fashion, with the desired end-products being thin and narrow blades, as well as broad quadrangular-shaped flakes. Despite a similar basic algorithm of recurrent blank production and surface preparation with the help of centripetally removed flaking surface flakes and lateral core edge flakes, the method of core reduction shows no parallel to any of the Hummal industries. Levallois blades and flakes were produced in equal parts with the recurrent unidirectional or bidirectional method, and corresponding technological attributes are visible on the end-products and core trimming elements. Unidirectional first, second, and third order blades occur next to blanks with bidirectional scar patterns (Fig.121, Nr.1, 3). The flaking axis always neatly followed parallel directions and no inclination to either side of the core edge is observable. Furthermore, the primary striking platforms remain limited to the proximal or proximal and distal end. As in the Hummal Mousterian, they were systematically faceted. The considerable number of striking platform flakes suggests a careful preparation of the lower core surface, which is also evidenced by some of the Levallois cores. Levallois points were of no importance as only one point and one point core were identified; convergent scar patterns are completely lacking in the analyzed sample. Blank size falls in between 7 and 3cm, whereby no difference exists between flakes and blades (Tab.56). The blades are very elongated with a mean LWR of 2.9 and are thereby comparable to the most laminar assemblages of Hummal (e.g. level 5a4, 5b7). The number of Levallois cores comes up to nearly two-thirds of the complete Hummal sample. Unlike in Hummal, they were not opportunistically exploited prior to exhaustion, and hence retain the characteristic attributes of applied Levallois methods (Fig.121, Nr.2, 4). Two main groups are differentiable, one comprising waste cores with bidirectional scar patterns, the second comprising lineal core types showing one final removal in the center; the production of preferential flakes seems to have been an efficient reaction to decreasing core volume. Only a small proportion of Levallois blanks were modified into tools, and retouch covers only a restricted part of the edge in most instances. Such a scarcity of retouched tools was also observed in the Hummal assemblages; however, it is interesting to note that side scrapers or Mousterian points are incidental or lacking, whereas notched pieces are relatively frequent.

To conclude, the techno-typological composition of the Nadaouiyeh P50 sample does not reveal any similarities to one of the Hummal Mousterian levels. Unfortunately, its relative chronological position remains unclear. The idiosyncratic features of the trench P50 sample, which are probably caused by a different mode of raw material provisioning and technological gestures compared to Hummal, allow an assessment of the significant variability concerning Mousterian technological organization in the El Kowm region and underscore the challenge of a quest for the causing factors.

9.2.2 Comparison with Umm EL Tlel

The spring-related site of Umm El Tlel probably reveals the longest Mousterian sequence known so far in the El Kowm region. The sedimentological context, showing an alternation between freshwater carbonates and palustrine formations, is roughly comparable to Hummal. More than 60 well-preserved archaeological levels allow an exceptional insight into Mousterian subsistence strategies, lithic organization and technology (Al Sakhel 2004; Boëda & Muhesen 1993; Boëda et al.1998, 2001, 2007, 2008; Bonilauri et al. 2007; Griggo 1998b). Moreover, Umm El Tlel is one of the few Near Eastern sites which deliver a continuous transition from the Middle to the Upper Paleolithic (Bourguignon 1998), and more than 30 Upper Palaeolithic levels are contributable to the Levantine Aurignacian and Ahmarian (Ploux 1998; Ploux & Soriano 2003).

Concerning the excavated part of the Mousterian sequence, two major chronological subdivisions based on TL-dates were defined. The first is a terminal Middle Paleolithic (*Paléolithique moyen final*), of which the upper part (complex IV) is dated to around 42 ka BP and the lower part to around 68 ka BP (Boëda et al. 1996, 1998). It is followed by an upper Middle Paleolithic (*Paléolithique moyen recent*) including complex VI, which is dated to around 70ka BP, followed by complexes VII and VIII (Boëda et al. 2008). Published lithic data suitable for comparison with the Hummal Mousterian are available for eight levels:

- *level V2βa* (Boëda & Muhesen 1993; Boëda et al. 2001; and personal observation): the assemblage shows a unidirectional recurrent and preferential production of Levallois points which seems to be comparable with the method of core reduction in the HM-A2 industry of Hummal. However, many points and Levallois flakes are relatively broad and short; in addition, evidence for a bidirectional flaking method is found on blanks and waste cores. Another distinguishing element is the presence of many oval and quadrangular-shaped flakes, which are rather scarce in HM-A2. In general, core reduction seems to have been pushed farther than in any of the HM-A assemblages, as can be seen by the abundance of small waste cores and a higher average of dorsal scar numbers on Levallois blanks. Yet a common aspect is the evidence for a site-provisioning strategy, including prepared cores and flint pebbles from secondary outcrops. The typological profile shows differences, notably because of a considerable number of notched pieces and denticulates, which are rare in Hummal.
- *level V2γ/Δa* (Boëda & Muhesen 1993; Al Sakhel 2001, 2004): viewed on broader scale, level V2γ/Δa is comparable to the HM-A industries due to the presence of Levallois points and many one-axis Levallois cores. However, the fact that points account for not more than 9% of all Levallois blanks and that around 40% of all blanks

were produced with the bidirectional method clearly sets this level apart from the point-dominated Hummal assemblages. In addition, the tool sample comprising many notched pieces and denticulates is different from the typological profiles in Hummal.

- *level V2πb* (personal observation): a one-day examination of a small sample revealed that this level contains a considerable number of Levallois blades; Levallois points are rather scarce. The blanks are more elongated than their counterparts in level V2βa, and hence, level V2πb shares this laminar character with many levels belonging to the HM-A2 industry of Hummal. However, the low number of points and related by-products can be seen as a significant difference between both sites.
- *Level VI1a0* (Boëda et al. 2001): only 16 artifacts were found in this level, which probably represents a place of butchery. Notable is the presence of large limestone blocks, as such pieces were equally found in level 5a3 and 5b2 of Hummal.
- *Level VI3a'* (Bourg 2007): the techno-typological examination revealed that Levallois points were desired end-products, the largest of which were probably imported. On-site core reduction followed the recurrent unidirectional and bidirectional pattern. As evidence for the latter is only incidental in Levallois point assemblages of Hummal, level VI3a' is not clearly relatable to any of the HM-A industries. Nevertheless, the presence of large, broad-based Levallois points with more than 3 dorsal scars is a feature which is also found in HM-A1. Moreover, the abundance of cores on flakes which exhibit the same reduction concepts as the cores in Hummal is another common aspect. Affiliations are also seen in terms of lithic organization, as prepared cores as well as blanks were imported and Levallois cores are rare.
- *Level VI3b'* (Boëda et al. 1998): the assemblage's composition and technological signature are comparable to level VI3a'. Characteristic blank types are Levallois points, which were produced using variable reduction strategies; large points were presumably imported; the significant presence of points with opposed and perpendicular preparation scars is a feature that is rarely observed at Hummal. Many points seem to have a relatively broad base, which suggests that at least the management of Levallois point cores is roughly comparable to HM-A1. This affinity is further undermined by a relatively high number of ventrally retouched Levallois points.
- *Level VI3b'1* (Boëda et al. 2001): the assemblage composition and the pattern of core reduction resemble the HM-A material in the sense that Levallois points predominate and are accompanied by quadrangular flakes. The initial phase of core reduction saw unidirectional and bidirectional blank removals; later, the unidirectional convergent

method became more important. As in the Hummal Mousterian, a considerable number of points were produced with the lineal method, especially in the latest stage of core exploitation. Judging from the few illustrated artifacts (Boëda et al. 2001, Fig.17), a comparison with the HM-A1 industry is most possible as broad-based Levallois points with strongly converging scar patterns seem to be characteristic blank types.

- *Level VI3c'* (Al Sakhel 2004): the method of core reduction is identical to level VI3b'1, with large Levallois blanks exhibiting a bidirectional scar pattern, whereas unidirectional patterns predominate in the smaller-size range; the tool sample is surprisingly rich in denticulates and notched pieces, which account for 47% of the total sample.

The mentioned comparisons between the Umm El Tlel and Hummal Mousterian make clear that some general techno-typological aspects are similar. To be mentioned is the predominance of triangular blank types and related convergent production methods, the frequency of the recurrent unidirectional method in the final stage of core exploitation, the intrinsic relation between recurrent and preferential Levallois points, and the presence of certain tool types, such as ventrally retouched Levallois blanks. Moreover, some Umm El Tlel assemblages show similar facets of lithic organization, namely raw material import in the form of prepared cores and blanks, raw material recycling and Levallois core export. The fact that in many levels of complex V and VI a considerable number of Levallois points exhibit a broad base, a *chapeau de gendarme* and complex scar patterns with strongly converging removals, supports an affiliation of these levels to the HM-A1 industry of Hummal. However, the variability of Levallois point production methods and the systematic reduction of cores from two opposing platforms are clearly distinguishing elements. In the Hummal HM-A industries, Levallois blank production exclusively followed a unidirectional pattern; the bidirectional and centripetal flaking methods were only incidentally applied (Fig.60). It has been observed that in Umm El Tlel, the bidirectional Levallois method was mainly executed during the initial phase of core reduction, whereas unidirectional scar arrangements are preferentially found in the lower-size classes. As the site is situated closer to the Bishri flint outcrops than is Hummal, evidence for the bidirectional flaking method could be scarcer in Hummal due to a distance-decay relationship. In other words, if the bidirectional production of Levallois blanks required large cores, their frequency would decrease as soon as transport costs increased. Unfortunately, we lack any primary data to test the significance of this assumption. However, even if the lack of bidirectional scar patterns in Hummal can be explained away by the distance to raw material outcrops, in the present state of research other aspects still support the impression of both sites showing different Mousterian technologies. For instance, a difference is constituted by quadrangular or oval-shaped Levallois flakes with centripetal scar patterns which seem to be relatively frequent in point-dominated assemblages of Umm El Tlel, whereas in Hummal they are incidental. Moreover, the typological profile between both Mousterian sites is often deviating. Although ventrally retouched implements occur in some HM-A assemblages of Hummal, they never attain the frequency they have in the complex VI3 assemblages of Umm El Tlel; a similar discrepancy exists for notched pieces and denticulates. Judging from the published data, none of the Umm El Tlel assemblages matches the Hummal HM-A2 levels, which contain narrow, elongated Levallois blades together with an abundance of blades and elongated flakes. In Umm El Tlel, an indication for the existence of laminar assemblages is given below complex VIII (Eric Boëda, personal communication 2006).

Given these differences, it is highly likely that complexes IV, V, and VI of Umm El Tlel represent a late Mousterian that is missing in Hummal. Nevertheless, the general similarity of the HM-A1 industry with some Umm El Tlel assemblages could suggest that at least the uppermost part of the Hummal sequence chronologically overlaps with the late Mousterian at Umm El Tlel. This would imply that Hummal levels 5AI to 5AVI can be roughly placed at around 70ka BP, whereas the HM-A2 industry is probably older than that.

Lithic analysis and archaeozoological investigations of certain late Mousterian assemblages in Umm El Tlel have shown that the functions of the site and its ecological context differed drastically (Boëda et al. 1998, 2001). The range goes from levels with a high density of lithic and faunal remains, such as layer V2βa, to horizons showing a sparse concentration of lithics together with a plenty of faunal remains, as in layer VI1a0. According to the authors, the site was repeatedly visited by Mousterian hominids for different purposes, which could have been butchering activities, meat processing, hunting or prolonged habitation. The animal food procurement and processing strategies left their trace in differential body part proportions of camelids and equids, depending on the size of the hunted prey and the function of the site (Griggo 1998a, 1998b, Boëda et al. 2001). Although relevant data are not to hand, from personal observation it seems that many Mousterian levels of Umm El Tlel reveal a considerably higher find density compared to Hummal. This difference can be explained by several reasons. First, it is possible that the well construction in Umm El Tlel did not affect the Pleistocene sequence as significantly as it did in Hummal. Thus, excavation in the former site gives access to the core area of Mousterian occupations, whereas in Hummal a substantial part of the settlement traces are missing. Second, the excavated surfaces are smaller in Hummal, and therefore the density of artifact concentrations may change considerably with future excavations. Third, it is possible that the sites played different roles in the settlement pattern of late Mousterian hominids in the El Kowm area. Umm El Tlel is situated closer to primary raw material outcrops than Hummal, and thus, its provisioning costs for flint were lower. In addition, we cannot exclude isochronic differences in microtopography, water table fluctuations and ecological context between the sites. If there were such differences, the two localities would have offered different resource supplies and settlement opportunities within an arid environment. And even when both sites showed a similar environmental setting, the chances are high that one of the springs served as a habitation site whereas the other served as a task locality, and vice versa; the distance of around 10 km between the two sites means that they are well within a one-day foraging radius. Although facies correlations are not yet established between Hummal and Umm El Tlel, it is possible that at some points in time, both sites had the same function. Viewed from a broad perspective and with the available data to hand, an alternation between a prolonged habitation in times of reduced spring activity and short-term visits during high-water stands is seen in both the springs of Hummal and Umm El Tlel.

9.2.3 Comparison with Douara Cave

The Douara cave is located around 70km from Hummal in linear distance. This small cave is situated in the southern slope of the Jebel ad Douara, about 18km northeast of the city of Palmyra (Akazawa et al. 1973). Excavations from 1970 until 1984 revealed a Paleolithic sequence covering two Epipaleolithic levels (complexes IIA and IIB) and four Mousterian levels (IIIA, IIIB, IVB, IVC) (Akazawa 1974, 1979; Nishiaki 1989). The lithic assemblages of complex IV show affinities to the so-called Early Levantine Mousterian facies or Tabun D type Mousterian. Significant in this respect is the relatively high blade index (62 for level IVB and 61.9 for level IVC) and the evidence for prismatic blade production (Nishiaki 1989). Of interest for a comparison with the Hummal assemblages are Mousterian levels IIIA and IIIB, which are separated from the lower deposits by a major depositional hiatus (Akazawa 1979).[34]

In both levels, characteristic blank types are broad Levallois flakes with centripetal scar patterns, blades with bidirectional scar patterns, and many Levallois cores exhibiting a

[34] Level IIIB was dated by ESR to 77 ± 9ka (early uptake) and 57 ± 15ka (linear uptake), but the reliability of these datings is questionable, and they are probably too young in the light of techno-typological considerations (Kai et al. 1987, cited in Shea 2003 ; Miki et al. 1988, cited in Shea 2003). Techno-typological analysis was done on two separate samples. Because of a change in the stratigraphic system used between the earlier and later excavations, the two samples cannot be put together. A detailed comparison with the Hummal material is principally hampered by a lack of metric data, a lack of total counts for the 1974 sample, and the summary definition of artifact categories. For instance, the study of the 1974 sample did not distinguish Levallois points from flakes and blades (Akazawa 1979). To overcome these analytical inconveniencies, the author tried without success to receive a permit for analysis of the Douara collection, which is housed in Museum of Palmyra.

recurrent centripetal or preferential flake-oriented exploitation. Levallois points seem to be underrepresented; in the 1970 sample, points account for not more than 11% in both levels. This technological pattern evokes similarities to the lowest levels of Hummal, which are grouped in the HM-B industry. Although the small sample size of the Hummal assemblages precludes any definite conclusions, it seems that the Douara III levels show a stronger focus on the centripetal method of core reduction, whereas Hummal levels 5e, 5f1 and 5f2 contain a higher number of flakes and blades which were struck from unidirectional prepared cores. It is possible that the variability in core exploitation methods between the sites is a result of different provisioning strategies. Suitable raw material is found not more than 1km away from the Douara cave, and several workshop sites in the vicinity of the cave attest a pretreatement of raw material (Akazawa 1987); furthermore, the significant number of abandoned nodule cores in levels IIIA and IIIB with a mean length of 6cm suggests that no constraint was posed on the supply of raw material. In contrast, at Hummal the transport distance for raw material was significantly higher. The significant importation of Levallois blanks could explain the markedly higher Levallois index (restricted IL) of Hummal levels 5e (IL = 90), 5f1 (IL = 80) and 5f2 (IL = 89) compared to the lower indices recorded for the 1970 sample of Douara (IL around 70). Although probably influenced by small sample size, the laminar index (Ilam) seems to be higher in the Hummal levels (between 40 and 68) than in Douara III (between 30.2 and 47.7 in the 1970 sample).

Based on the mentioned technological aspects, Douara levels IIIA and IIIB were placed into the Middle Middle Palaeolithic or Phase 2 / Tabun-C phase of Copeland’s tripartite division of the Mousterian (Copeland 1975; Akazawa 1987; Shea 2003). Despite the sample size and dating problem in Douara and Hummal, this general correlation would allow us to tentatively place the lowest Mousterian levels of Hummal into the middle part of the Levantine Mousterian. The techno-typological affinity between Douara III and the lower Mousterian levels of Hummal is an issue that has to be worked on with more material to hand, the possibility of conducting a reexamination of the Douara material, and a better assessment of possible site functions in the lower Hummal levels.

9.2.4 Comparison with Jerf Ajla Cave

The Jerf Ajla Cave is located near the city of Palmyra in a dry valley around 80km southwest of Hummal. During the initial excavation, carried out by A. Coon in 1955, a significant amount of sediment was removed and a large quantity of artifacts discarded. In 1965 the site was reinvestigated by B. Schroeder, who described the geological and archaeological sequence, ranging from an Acheulian level at the base to late Mousterian / Early Upper

Paleolithic assemblages at the top (Schroeder 1969). Subsequent geoarchaeological investigations combined with a dating program gave new insights into site formation processes and established the chronological position of layer C, which delivered a mean TL age estimate of around 33 ka BP (Julig et al. 1999; Richter et al. 2001). This layer contains Mousterian as well as Upper Paleolithic elements and correlates well with the “transitional” Mousterian of Umm El Tlel. For a comparison with the Hummal sequence, Mousterian layers F to D are of interest. Schroeder ascribes layers E and F to an Early Levantine Mousterian due to the high number of blades (both Levallois and prismatic), the presence of elongated points, the predominance of unidirectional production methods, and the abundance of Upper Paleolithic tool types (Schroeder 1969). Judging from artifact illustrations and technological data, both assemblages are in fact reminiscent of the lowest Mousterian deposits at Tabun (see chapter 9.3.1). Although many Hummal assemblages reveal equally high proportions of blades and laminar indices between 40 and 60, as well as similar-looking elongated Levallois points, all other technological aspects are different. In Jerf Ajla F and E, a variety of methods were applied for blade production, ranging from the exploitation of pyramidal and tablet-shaped prismatic cores to large bipolar Levallois cores. The faceting index is relatively low compared to Hummal, due to many blank removals from plain platforms. Although data concerning core trimming elements and flake scar patterns is lacking, it seems that Levallois point production was less standardized and did not play the dominant role that it did in the upper part of the Hummal sequence. Unfortunately, Schroeder found only 10 artifacts in layer D and had to rely on the retained sample of Coon. Interestingly, he stated that, compared to the underlying levels, assemblage D shows a strong technological convergence of Levallois blanks, in the sense that a considerable homogeneity exists between blades, flakes and points in terms of surface preparation. Although Schroeder did not pursue this impression analytically, his postulation of an increased technological homogeneity in level D can be seen as an increasing standardization in Levallois technology coinciding with a high faceting index (IF) of 75.3. The Levallois points are strongly reminiscent of elongated specimens found in Hummal levels 5a3, 5a4, 5b7, 5DV and 5E. Despite the evidence for a continued non-Levallois blade production and bipolar reduction of Levallois cores, Jerf Ajla level D seems close to Hummal HM-A2. However, we have to remain cautious, as the layer D sample is incomplete and technological data are scanty. It is therefore important to re-examine Jerf Ajla level D in light of possible correlations with the Hummal Mousterian.

9.2.5 Comparison with Yabroud

The rock shelter site Yabroud I is located around 80km north of Damascus on the western face of the Skifta dry valley. The site, which reveals Lower and Middle Paleolithic deposits, was extensively excavated in the 1930s by Alfred Rust, who published the results in detail (Rust 1950). An additional test trench was excavated in the 1960s by the Columbia University mission (Solecki & Solecki 1966), coupled with brief stratigraphical investigations in 1987 and 1988 (Solecki 1986). The Mousterian deposits span the upper two meters, and Rust defined 10 archaeological levels (called *Kulturschichten*) in different sections. The spatial relationship between these levels remains unclear, as the 1960s test trench did not reveal the entire sequence that Rust had discovered across the rear of the shelter. Hence, the cultural integrity of the ten *Kulturschichten* (labeled "KS" henceforth) is an unresolved problem which has to be borne in mind when dealing with the technological variability of the Yabroud Mousterian (Solecki & Solecki 1995). Rust's collection is housed in the *Institut für Ur- und Frühgeschichte der Universität zu Köln,* and despite a certain bias due to selection, can be seen as a reliable sample for lithic studies.

By reinvestigating the Rust collection, Solecki & Solecki (1995) defined two basic Mousterian variants called YMI (KS 2-4, 6, 8, 10) and YMII (KS 5, 7, 9). Although they discussed some technological aspects, the bulk of their conclusions rest on typological considerations focusing on retouched tools. The basic difference between the two variants is that YMI is clearly dominated by the Levallois flaking method and Group II- tools, although a significant amount of Upper Paleolithic tool types are equally found, especially in KS 3 and KS 8. The YMII variant bears evidence of prismatic blade production parallel to Levallois reduction methods and a predominance of Group III-tools, as well as notches and denticulates. KS 5 stands out due to the small size of artifacts, which are mostly smaller than 5cm. Hence, it is often referred to as a Micro-Mousterian.

To better understand the technological tendencies and to enable a comparison with the Hummal Mousterian, we carried out a rapid analysis of the Yabroud lithics with a focus on KS 2 and KS 10. In all levels, the considerable raw material diversity poses a challenge for the identification of technological patterns. Solecki & Solecki (1995) distinguish between allochthonous high-quality flints or cherts and a local, low-quality Yabroud variety, all of which are unknown in respect to their provenience. Alluvial neocortex can be found on many pieces, and it is highly likely that the major bulk of raw material was collected in nearby wadi deposits. According to Solecki & Solecki (1995), reduction intensity seems largely independent of the flint variety used. Their results rather suggest that the local variety's exploitation was less structured, resulting in many informal tools and discoid-type or

Levallois-like cores. In addition, some levels (for example, KS 8) reflect the importation of tools made of better-quality raw material. As we were not able to draw a clear line between the allochthonous and local flint varieties due to a lack of respective data in our study, the following considerations concerning the techno-typology of some Yabroud Mousterian assemblages are unfortunately devoid of this cross reference.

Before presenting KS 2 and KS 10 in more detail, something should be said regarding certain levels in between. KS 8 and KS 6 are point-dominated assemblages in which the triangular blanks exhibit a marked elongation (see also Solecki & Solecki 1995). The fact that many points were produced in a unidirectional-convergent mode evokes some similarities with the HM-A2 industry of Hummal. Point production was accompanied by the removal of preferential flakes from centripetally prepared cores; the variability of blank forms seems to be higher in KS 8 than in KS 6. The small size of blanks and cores in KS 5 seems to be related to a high degree of raw material reduction. A considerable number of small waste cores show traces of bidirectional bladelet or centripetal flake production. In addition, many small flakes in the range of 1-3cm were obtained on cores on flakes. The "micro-like" impression could also result from provisioning the site with small-sized wadi pebbles, as many blanks and cores exhibit patches of neocortex. However, the presence of Levallois points and blades with a length between 5 and 6cm shows that the microlithization is rather a result of reduction intensity than of raw material size. Characteristic blank categories are Levallois points, many of which exhibit a *chapeau de gendarme*-type of butt. The alleged frequency of Upper Paleolithic tools in most of the Yabroud levels has to be regarded with caution. A considerable number of burins are in fact cores on flakes of the ventral- or multiple-type or edge damaged pieces; this concerns every level.

We chose the two endpoints (KS 2 and KS 10) of the Yabroud Mousterian sequence to have representative samples to hand in case a linear technological trajectory exists. Due to time constraints, only end-products were taken for a closer study.[35] Solecki & Solecki (1995) pointed to the laminar aspect of both assemblages and tentatively ascribed them to an early phase (Tabun D) of the Levantine Mousterian, on the basis of elongated points and many Upper Paleolithic tools (see also Copeland 1975). Our results in fact confirm the considerable number of elongated points and blades in both levels, but disagree with the correlation to an Early Mousterian as concerns KS 2. Both samples are quite similar in respect to Levallois blank type proportions, except that the number of blades is higher in KS 10 than in KS 2. The

[35] We are aware that the focus on end-products neglects valuable information which can be gained by an analysis of core trimming elements and cores. Nevertheless, this information gap can in part be closed by reference to the data provided by Solecki & Solecki (1995, Tables 4 and 6).

laminar aspect is clearly reflected by high blade indices (Ilam) and a high mean length-width ratio (Tab.57).

Despite these general similarities, the Levallois blanks' technological attributes reflect a clear difference in production strategies. First of all, the blanks in KS 10 are significantly smaller than their counterparts in KS 2 (Tab.58). This size difference is statistically significant irrespective of blank type. Interestingly, the higher mean of relative thickness (RT) values in KS 10 shows that the size difference is not just the result of smaller flaking surfaces exploited with the same technique. If this were the case, the relative thickness should be positively correlated with the horizontal flake dimension, and hence, RT values should be lower compared to KS 2. The constantly high thickness in relation to average flake length and width in KS 10 is an indication that the flaking surfaces were of a domed or even prismatic shape. A corresponding observation is the marked central ridge and steep inclination of dorsal faces on many Levallois blades and points, as well as the presence of many longitudinally twisted pieces. As no prismatic cores were identified by the Soleckis, it is unclear whether a true prismatic blade production occurred in KS 10.

The frequency of dorsal scar patterns reveals further technological differences between KS 2 and KS 10 (Fig.122). In both levels, more than 50% of flakes and blades exhibit a unidirectional pattern (see also Fig.123, Nr.7). As in the Hummal Mousterian, it is highly likely that a significant number of these blanks had a predetermining function and were intrinsically related to Levallois point production. In KS 10 many preferential flakes were struck from centripetally prepared cores (Fig.123, Nr.8), whereas the centripetal scar pattern in KS 2 relates to Levallois blanks initiating a recurrent production. Two opposing platforms were preferentially used for blade production in KS 10 (Fig.123, Nr.6) whereas in KS 2 they served for variable reduction aims, including many Levallois point removals (Fig.123, Nr.1, 3). In KS 2 about one-third of all Levallois points are of the "classical" type, showing three converging negatives. While these points were all struck from one platform, the remainder were produced from either one or two opposing platforms.

In general, the Levallois points of KS 2 reflect a high degree of standardization, with carefully prepared butts including many *chapeau de gendarme* types (73%). The reverse is true for assemblage KS 10, in which 27% of all points lack a faceted butt and only 34% exhibit a *chapeau de gendarme*. In contrast to KS 2, more than two-thirds of the points were struck from a single platform; the bidirectional scar pattern was found only on a few highly symmetrical pieces, which are identical to some of the points in KS 2 (Fig.123, Nr.2). A characteristic feature of KS 10 is the presence of many blades which exhibit a plain butt (38%). The difference in platform trimming between KS 2 and KS 10 is observed for all blanks and results in a considerably lower faceting index (IF and IFs) in KS 10 compared to KS 2 (Fig.123). Despite the technological differences, both levels show comparable typological profiles (Tab.59).[36] Taken together, partially retouched Levallois blanks and simple side scrapers amount to over 50% of all retouched implements. The second most frequent tool category comprises more intensively retouched pieces, such as double-side scrapers and Mousterian points, some of which are elongated (Fig.123, Nr.4). End scrapers are mostly atypical, in contrast to the burins in KS 2, which are all well-made, typical specimens. Notched pieces and denticulates are rare in both levels.

The mentioned technological aspects have to be cross-checked by a petrographic analysis in order to see whether the differences between KS 2 and KS 10 are the result of varying provisioning strategies. In both levels, according to Solecki & Solecki (1995, Tab.10), the local Yabroud flint is the dominant raw material category. From a broad perspective, a common feature between Yabroud KS 2 and KS 10 and the Hummal Mousterian is the marked elongation of Levallois blanks (Tab.57) and the relatively high number of Levallois points with related flakes and blades showing unidirectional scar patterns. However, comparing the overall pattern of dorsal scar arrangements between both sites shows that the point-dominated Hummal assemblages with their predominance of one-axis core exploitation strongly contrast with the more variable spectrum of flaking techniques in the Yabroud levels (Fig.124). Decisive is the recurrent bidirectional flaking method, which generated many points in KS 2 and blades in KS 10 and which was applied only incidentally in the Hummal assemblages. Only the lowermost Hummal levels 5e-5f2 contain even more bidirectionally produced blanks; however, their assemblage composition is radically different from the Yabroud samples. Furthermore, the high number of centripetally prepared flakes in KS 10 sets this level apart from the Hummal Mousterian. Restricting the comparison to Levallois points shows that the point-dominated assemblages of Hummal reflect a high degree of technological standardization in the sense that the unidirectional convergent flaking method was the predominant means of point production, whereas the knappers in Yabroud followed more variable concepts (Fig.124). Moreover, a considerable number of triangular blanks with a unidirectional parallel pattern in KS 10 are actually not true Levallois points and received their pointed shape rather accidentally; it is important to note in this respect that no Levallois point cores were identified in this assemblage (Solecki & Solecki 1995, Tab.7).

To conclude, the technological traits of the KS 10 assemblage are reminiscent of Early Levantine Mousterian assemblages, such as Tabun unit IX (see chapter 9.3.1). To be mentioned are many blades and flakes with a plain butt, the low *chapeau de gendarme*

[36] The tool counts closely match those made by Solecki & Solecki (1995, Tab.3).

frequency, the predominance of blades and elongated points, and the possible evidence for a prismatic non-Levallois flaking concept. In contrast, assemblage KS 2 reflects a standardized Levallois point production aiming at elongated as well as short, broad-based specimens. This aspect, together with the predominance of flakes and the high faceting index, warrant a tentative attribution of KS 2 to the group of point-dominated Late Levantine Mousterian assemblages. The same probably holds true for underlying levels KS 3 and KS 4, as they closely resemble KS 2 in terms of reduction strategies and Levallois point morphology (Frank 2004; Solecki & Solecki 1995). The presence of short, broad-based points and the high number of blanks with a *chapeau de gendarme* allows a correlation of Yabroud KS 2-4 to the uppermost Mousterian levels of Hummal (HM-A1 industry), despite a difference in the chosen flaking methods. The significant technological variability in the Yabroud Mousterian is probably related to raw material diversity, whereas in Hummal, the inter-assemblage homogeneity in flaking concepts mirrors the focus on a single, high-quality flint type.

9.3 Moving to the west: a comparison between Hummal and Tabun units IX and I

The well-known cave site of Tabun was extensively excavated by D. Garrod between 1924 and 1934 and by A. Jelinek from 1967 to 1972, and has been reinvestigated since 1975 by A. Ronen. Information concerning the site, its geological and archaeological sequence can be found in relevant publications (Albert et al. 1999; Garrod & Bate 1937; Jelinek et al. 1973; Jelinek 1981, 1982a, 1982b; Ronen 1982). Its long Paleolithic sequence makes Tabun a key site in the Levant and frequently serves as a reference for the definition of technological development in the Middle Palaeolithic. Supporters of the tripartite stage model for the Levantine Mousterian use Garrod’s levels D, C and B as type-assemblages for the Early, Middle and Late Mousterian respectively. A comparison of Hummal with Mousterian assemblages from Tabun will therefore provide an informative basis about its relative chronological position in the long time-span which covers the Levantine Mousterian. As our focus is on Mousterian lithics, the following section deals exclusively with data obtained during a study of unit IX and unit I assemblages of the Tabun collection, excavated by Jelinek and currently housed at the University of Arizona, Tucson. Unfortunately, during his excavation, Jelinek found only small remnants of Garrod’s layer B, which is reported to contain an abundance of Levallois points (Jelinek et al. 1973). Thus it was impossible to oppose the point-dominated levels of Hummal to the key-assemblage of the Late Levantine Mousterian. Nevertheless, study of lithics from Tabun unit IX allowed us to eradicate our inconclusiveness as to whether the abundance of elongated points and blades in Hummal levels 5a2 to 5E are potential signs of an Early Mousterian phase in this site.

9.3.1 Tabun unit IX

Tabun beds 63-68 were chosen for a detailed techno-typological analysis. Although a selective bias is certainly reflected by the relatively high proportion of blanks (63.4% of the debitage sample) compared to core trimming elements (36.6%), the Tucson collection of Tabun unit IX can nevertheless be seen as a reliable sample (Jelinek, personal communication, 2008); this impression is corroborated by the fact that the core trimming elements are representative of all core reduction stages (Tab.60). As the studied assemblages are only samples of the entire collection from Jelinek's excavation, the quantitative difference between beds 63-68 and sub-levels 66B and 66Q cannot be meaningfully interpreted.

Important features of unit IX are the predominance of elongated blanks, a relatively high percentage of Levallois points and blades, both Levallois and prismatic (Tab.60 and Tab.61). The presence of non-Levallois blades and flakes generated by the reduction of prismatic-shaped cores suggests that an alternative flaking technology was applied next to the Levallois method (Fig.125, Nr.1-3). A crucial question is whether both technologies represent separate *chaînes opératoires* or whether they are interrelated in the sense that one can switch from a prismatic blade production to a Levallois concept on the same core. Addressing this question, relevant technological attributes, on the basis of which both technologies can be distinguished, are presented first. Discriminative features are the blanks' shape and the maintenance of the striking platform. Both technological categories reveal similar-sized blanks, but the volume distribution is different (Tab.54). Prismatic blades are the most elongated blades in the assemblage, with a mean LWR of 3.3. Elongation is coupled with an arced cross-section, the result of setting the blow deeply below a prominent central ridge (Fig.125, Nr.2-3). The difference in volumetric conception between Levallois cores and prismatic cores can be expressed by a distinct constellation of metric values, shown by the corresponding end-products. Non-Levallois blades are narrower and thicker than Levallois blanks and therefore exhibit a lower width-thickness ratio (WTR) and higher edge angles. In this sense, prismatic blades are more robust than Levallois blades, which certainly had an effect on the functional properties of both blade types. Moreover, some Levallois blades, especially those in bed 66, are extremely thin and narrow, and it is possible that they were produced with a soft hammer (Fig.125, Nr.12).[37]

The difference in platform maintenance between both technologies is reflected by a stronger investment in platform shaping on Levallois cores than prismatic cores (Tab.62). The latter were mainly exploited by roughly prepared platforms, whereas Levallois blanks were systematically struck from faceted striking platforms. Nevertheless, the considerable amount of Levallois flakes, blades and points with unprepared platforms can be taken as hinting at an interrelationship between both methods. In addition, the mean flaking angle of all blank categories is identical, ranging between 108° and 112°. Scar pattern analysis reveals that in both technologies, cores were mainly exploited on the basis of one platform; because some Levallois flakes and blades exhibit bidirectional scar patterns, it can be assumed that the recurrent bidirectional Levallois method was an alternative strategy, at least during the earlier stage of production (Fig.125, Nr.8, 9, 11, 12). Most frequently, reduction either followed unidirectional parallel or unidirectional converging directions (Fig.125, Nr.4-7, 10, 13-15). About 25% of all Levallois blades and flakes exhibit converging scar patterns and a sub-triangular shape, and these features relate them to the recurrent production of Levallois points. Levallois points account for 30% among all Levallois blanks and are accompanied by 5 point cores. The latter display an opportunistic exploitation during the last reduction stage and are therefore non-diagnostic in terms of flaking method. The majority of points are markedly elongated (mean LWR: 2.3; 75th percentile of LWR: 2.7) and exhibit a *chapeau de gendarme* (57%). The fact that 80% of all points show a unidirectional scar arrangement means that preparation of the flaking surface was carried out using one single platform. The earlier stage of core exploitation saw a recurrent unidirectional removal of long and narrow points of which the majority exhibits more than 3 anterior negatives and a relatively narrow base (Tab.63 and Fig.125, Nr.4, 14). During the later stage of core reduction, the knappers frequently switched from the recurrent to the preferential strategy, thereby producing mostly classical specimens with three converging negatives and a relatively broad base with a *chapeau de gendarme* (Fig.125, Nr.5). The same happened during Levallois flake production, as is evidenced by three preferential Levallois cores. As soon as the Levallois cores' volume reached a certain threshold at around 100 cm^3, they were either abandoned or further reduced by an opportunistic method, thereby leaving behind many simple flake and small, discoid-type waste cores. The nodule core group is accompanied by cores on flakes, the majority of which are of

[37] Although the evidence is scarce, it is possible that these large, elongated blades were the first removals struck from Upper Palaeolithic-like blade cores. This would explain the discovery of a crested blade in bed 64. With decreasing core volume, blade production probably became less structured and changed to the simple, prismatic concept.

the dorsal type. Blank selection for cores on flakes at Tabun followed the same strategies that we have already seen in the Hummal Mousterien. Large first flakes served for a production of Kombewa and Janus flakes, whereas Levallois blank and tool fragments were exploited on their dorsal face after the installation of a faceted striking platform on the breaking surface.

For the purpose of tool fabrication, mainly Levallois blanks were selected from the pool of flaked items (see ILty values in table 64). In addition, a significant number of prismatic blades (12% retouched) and cortical flakes (12% retouched) are found in the retouched tool sample. The longer the edge of a blank, the more apt it was for retouching, and hence, edge modifications are mainly found on blades and elongated points. The fact that many of these blanks show only a marginal retouch is probably to be correlated with the adjustment of shape, resharpening or ergonomic considerations. Among the more intensively retouched implements, simple side scrapers, double-side scrapers and elongated Mousterian points predominate (Fig.126, Nr.1, 2); consequently, the IR and Group II indices are the highest compared to other typological indices. Retouch on the ventral face is frequently found and can be seen as a characteristic element of the retouched blank sample (Fig.126, Nr.3, 4). Noteworthy are two non-Levallois blades, which were modified into typical Hummalian points (Fig.126, Nr.5). Upper Paleolithic tool types are rare but typical; likely, notched pieces and denticulates are incidental. The handaxes were probably procured from underlying levels.

From a general point of view, the assemblage composition of Tabun unit IX is reminiscent of the point-dominated assemblages in HM-A1 and HM-A2 of Hummal. During the initial investigation of levels 5a2, 5a3 and 5a4 in the western section of Hummal, the outstanding elongation of many Levallois blanks immediately provoked us tentatively to correlate these assemblages to the Tabun D complex. Elongated Levallois points, serial blade production and the significance of unidirectional reduction patterns are key features in this respect. The laminar indices of levels 5a3, 5a4, 5b1 and 5E (all over 50) in fact approach the extraordinarily high index of Tabun unit IX. Additionally, the length-width ratio of Levallois blades in levels 5a4, 5b7 and 5b5 is equal to or higher than the 2.8 value obtained for Tabun. Moreover, the predominance of elongated points with unidirectional scar patterns generated by the recurrent method is a common aspect found in both sites. However, a closer inspection reveals that lithic technology in Tabun unit IX was more variable, in the sense that different blank types were generated by independent reduction concepts. The lowest Mousterian assemblages of Tabun are clearly dominated by blades, and their production followed discrete patterns, whereas in Hummal they are intrinsically connected to the reduction of Levallois point cores; in this sense, we can corroborate the observation that L. Copeland used for her distinction between Phase 1 and Phase 3 Mousterian sites (Copeland 1975; see also Meignen

1998b). Moreover, the coexistence of Levallois and non-Levallois reduction sequences for blades in Tabun is absent in the Hummal samples, with their strict application of the Levallois method. Concerning the Levallois points, the Tabun sample displays a considerably higher length-width ratio than most of the Hummal samples (Fig.127). Furthermore, the Tabun points are narrower and thicker than the Levallois points found in Hummal, which is expressed by their lower width-thickness ratio. Hummal level 5a3 is the only assemblage which approaches the volume conception of Tabun points. Thus, the recurrent production of "leaf-shaped" points with a narrow base, which is mirrored by some assemblages in the middle part of the Hummal sequence, is technologically closer to the Tabun material than to other Levallois point technologies in Hummal (see chapter 6.5.1). It is interesting to note that the points of Yabroud KS 10 are morphologically closest to the Tabun IX points, and this corroborates the allocation of the lowest Yabroud Mousterian level to an early phase of the Levantine Mousterian.

9.3.2 Tabun Unit I

From Tabun unit I, equivalent to Garrod's layer C, we chose beds 18 to 22 for a detailed techno-typological analysis. The sample shown in Table 65 is mainly composed of complete debitage (> 2cm) and many fragmented pieces, of which the majority exhibit traces of intensive burning; this observation coincides with the evidence of several ash layers in unit I (Jelinek et al. 1973). The assemblage composition and technological features of unit I are radically different from those of the underlying unit IX. Levallois flakes dominate the blank sample, Levallois blades are underrepresented and Levallois points are incidental. Consequently, unit I is characterized by a markedly low Ilam of 28.9. The blanks were produced exclusively with the Levallois method; the few non-Levallois blanks stem from the final opportunistic core reduction or recycling of flakes. Except for one prismatic blade core in bed 38, we found no evidence for a non-Levallois flaking concept which paralleled Levallois core reduction. The fact that the blanks in unit I are significantly larger than their counterparts in unit IX corresponds with either a selection of larger raw material blocks during later Mousterian occupations or a difference in the exploitation of core volume (Fig.128). As there is no indication for a raw material-related influence, the size difference is due to completely different strategies of core reduction. In unit I, Levallois flakes and blades show a large size range with specimens as long as 13cm next to tiny flakes with a length between 2 and 3cm (Tab.66). The desired end-products of Levallois core reduction were large and broad Levallois flakes (Fig.129). To achieve this, the knappers frequently prepared a striking platform around the core's circumference and shaped the flaking surface in a rotating fashion. Subsequently, large flakes which extended over a significant part of the flaking surface were removed. These flakes are rather flat and squat, and exhibit a centripetal scar pattern on their dorsal face (Fig.129 and Tab.67). Both the recurrent centripetal and lineal Levallois method were applied for flake production; the lineal method was probably the preferred flaking strategy, as only 19% of all Levallois flakes exhibit one or more anterior blank removals on their dorsal face. The majority of flakes exhibit a polygonal or oval shape and faceted platforms (IF: 83.1; IFs: 75.9). In contrast to one-axis core reduction, which involves one principal striking platform, many flakes were struck from various positions on the cores' circumference, and therefore, a *chapeau de gendarme* is only found on preferential types. The recurrent centripetal and preferential flake production was accompanied by a uni- and bidirectional core exploitation to obtain elongated blades and flakes (Fig.129, Nr.2). It becomes clear that the totally different core reduction strategies in unit IX and I are represented among other things by varying volume distributions on the blanks. The recurrent unidirectional production of flakes and points in unit IX generates elongated, narrow and rather thick blanks, of which several were struck during one reduction stage. Contrarily, the centripetal flaking method allowed a removal of broader and flatter flakes, but consumed a much higher mass of flint during one reduction stage than the unidirectional blade production.

As is the case in unit IX, many Levallois cores were opportunistically exploited at the end of their use life, ending as simple flake cores from which thick and squat flakes were removed (Fig.129, Nr.6). Core exploitation was principally confined to one flaking surface, and only 2 out of 24 nodule cores exhibit blank removals on both faces. The centripetal, unidirectional and bidirectional scar arrangements visible on Levallois cores reflect the principal reduction strategies. Wasted cores of the lineal type evidence a continuous production of preferential flakes throughout the reduction sequence (Fig.129, Nr.9).

The rather small retouched tool sample is less diversified compared to unit IX (Tab.68). It is dominated by single-side scrapers fabricated on Levallois flakes (Fig.129, Nr.4, 10). Noteworthy is the absence of Upper Paleolithic tool types, the scarcity of double-side scrapers and the presence of pseudo-Levallois points, which can be seen as by-products of the recurrent centripetal flaking method. The low frequency of partially retouched blanks is probably related to the fact that the centripetal method allowed for a production of highly standardized blank morphologies, thereby reducing the need for shape corrections. The scarcity of intensively retouched specimens, such as double-side scrapers, is difficult to explain, and can be the result of an export of such tools, a lack of pressure for blank resharpening or just sample size.

Given the mentioned techno-typological features of Tabun unit I, a comparison with Hummal has to focus on the lowest levels 5e to 5g, which are grouped within the HM-B industry. In this respect, both sites share the evidence for centripetal core preparation for flake production and the bidirectional exploitation strategy to obtain large blades. However, there is no indication of the recurrent centripetal flaking method in the Hummal levels. Moreover, flakes are not the predominating blank category in Hummal, and it seems that elongated as well as short quadrangular tools were of equal importance; the HM-B industry has a much higher Ilam of 48.3 compared to Tabun unit I. As already mentioned, we have to await a future enlargement of the Hummal sample to be able to draw more definite conclusions as regards the allocation of HM-B to a Tabun C-type Mousterian.

9.4 Comparison of Hummal with other Late Mousterian sites: Kebara, Amud, Tor Faraj and Tor Sabiha

The previous comparisons with the lower Jerf Ajla assemblages, Yabroud KS 10 and Tabun unit IX have shown that the point-dominated Hummal industries HM-A1 and HM-A2 do not belong to the Early Levantine Mousterian complex, despite some general techno-typological similarities. The idiosyncratic features of Levallois point production, their typological profiles and their close resemblance to the Mousterian complexes IV-VI of Umm El Tlel rather warrant an attribution of the upper part of the Hummal sequence to a Late Mousterian. This assumption can be corroborated by comparing HM-A1 and HM-A2 with the Mousterian deposits of four published sites for which sufficient data is available: Kebara Cave, Amud Cave, and the two rock-shelter sites Tor Faraj and Tor Sabiha.

Kebara Cave is located on the western escarpment of Mt. Carmel about 2.5km west of the Mediterranean coast and 13km south of Tabun Cave (Bar-Yosef et al. 1992; Schick & Stekelis 1977) The 4m-deep Mousterian sequence is dated by TL into a range from 60 ka BP for level XII to 48.3 ka BP for level VI (Valladas et al. 1987). In all levels, evidence is given for Levallois point production, and especially in levels IX to XII the Levallois core reduction concept is strongly oriented towards this blank form (Meignen & Bar-Yosef 1991, 1992; Meignen 1995). In these levels, inter-assemblage differences in regard to applied flaking methods are discernible. The lower levels XII and XI distinguish themselves from overlying levels by a stronger laminar tendency, whereas in levels X and IX, short broad-based points, sub-triangular flakes and quadrangular flakes predominate. The point-dominated assemblages of Kebara share many techno-typological features with the Hummal assemblages 5AI to 5E. To be mentioned is the preference for the unidirectional convergent method, which in both sites generated the major bulk of blanks. Furthermore, the intrinsic relationship between the lineal and recurrent methods and the typical by-products of the latter (chapter 6.6) can be found in Kebara and Hummal. The Levallois point samples of Hummal HM-A1 and Kebara IX-XII are nearly identical regarding Levallois point technology. Also noteworthy is the recurrent and preferential production of triangular blanks involving systematic platform-faceting and *chapeau de gendarme* shaping, the strong convergence of scar patterns, and the exclusive use of a single striking platform (Tab.69). A significant difference concerns the blanks' elongation, with much higher proportions of elongated Levallois blanks in the Hummal samples (see Ilam values in Table 69. This is especially the case for points in Hummal HM-A2, as levels 5a2 to 5E lack short, broad-based specimens and contain many more elongated points and blades. Moreover, the frequency of convergent scar patterns and the degree of convergence in levels 5a2 to 5E is lower on average than in levels 5AII to 5AVI and in Kebara IX-XII. The typological profile of Hummal and Kebara is similar, with a dominance of the Mousterian group, which mainly comprises retouched points and side scrapers, and the scarcity of denticulates and notched pieces. The frequency of Upper Paleolithic tool types seems to be higher in Kebara, especially in unit IX, but this can be explained by our rigid definition of burins and truncated pieces in the Hummal sample (see chapter 6.11). Thus, in the present state of analysis, the uppermost Hummal assemblages 5AI to 5AVI reveal a close resemblance to Kebara levels IX to XII in terms of technology and typology. Subtle differences nevertheless exist and can be the result of differences in raw material size and quality, provisioning strategies, desired tool function or regionalization of technological traditions.

The inter-assemblage variability of reduction strategies and blank morphologies in the point-dominated Hummal assemblages is commensurate with the technological diversity found in the Late Mousterian deposits of Amud Cave. This important site, which is located on the margins of the Dead Sea Rift, revealed three Mousterian deposits (B1, B2 and B4), intercalated by a sterile layer (B3). The age range of these levels determined by TL and ESR is between 50ka BP and 70kaBP (Rink et al. 2001; Valladas et al. 1999). Layer B4 at the base contains classical broad-based Levallois points, while the scar pattern on the cores and debitage show a preference for the unidirectional convergent flaking method (Hovers 1998; Ohnuma & Akazawa 1988). The B2 assemblage is more variable and reflects two parallel flaking concepts, the unidirectional convergent and the recurrent centripetal method. A characteristic element of level B1 is the abundance of atypical, mostly elongated Levallois points and rectangular blades and flakes with unidirectional parallel scar patterns. As the initial stages of core preparation occurred off-site, the typical by-products of initial recurrent point production are elongated, semi-cortical removals with unidirectional scar patterns; this core trimming category equally marks the first stage of on-site production in Hummal (see chapter 6.6). The frequency of elongated, asymmetrical points with only slightly converging scar patterns in levels B1 and B2 is reminiscent of the “leaf shaped” points in the HM-A2 complex in Hummal. Moreover, the significance of elongated flakes and blades with unidirectional scar patterns in Amud B1 and in Hummal levels 5a2 to 5E reinforces this technological resemblance, although blades are much more common in the Hummal samples (Tab.69). By the same token, evidence for the production of centripetally prepared preferential flakes in the final stage of core reduction is found in both sites. Another common aspect is the high frequency of cores on flakes in Amud levels B1 and B4 (Hovers 2007) and the majority of the Hummal assemblages. To conclude, several lines of evidence suggest a close resemblance between Amud levels B1, B2 and B4 and the Hummal HM-A complex in terms of core reduction concepts and raw material economy; above all, nearly identical traits were found for Amud B1 and the HM-A2 industry of Hummal.

A strikingly good accordance to the Hummal Mousterian in terms of core reduction strategies and technological organization is also given by the two rock-shelter sites Tor Faraj and Tor Sabiha in Southern Jordan (Henry 1995a, 1995b, 2003). Level C (floor I and II) of Tor Faraj has been dated to around 70ka BP by acid racezimation of ostrich eggshells. The fact that in both sites core reduction was oriented towards point production and generated many blades, and the evidence of bidirectional core exploitation as an alternative to the unidirectional method, prompted Henry to interpret both assemblages as representatives of a late Tabun D Mousterian in the Southern Negev (Henry 1995a). However, comparison with other sites showed that Levallois point technology and typological features are unequivocally of Late Mousterian / Tabun B type. The high standardization and craftsmanship in Levallois point core exploitation shows parallels to Kebara units IX-X and Hummal HM-A1. The core reduction strategy was probably even more rigid in Tor Faraj, which is mirrored by the preference for the lineal method (Demidenko & Usik 2003). Thus, typical end-products are relatively short, broad-based points with 3 strongly converging negatives and a pronounced *chapeau de gendarme*. The technological rigidity seen in Tor Faraj probably explains the higher proportion of Levallois flakes and the lower length-width ratio of points in comparison with Hummal, where the unidirectional recurrent method was frequently chosen to obtain elongated blanks (Tab.69); however, it has to be stressed that in both sites, a significant quantity of blades are by-products of Levallois point core reduction (chapter 6.4.3).

Concerning the retouched tool sample, Tor Faraj and Tor Sabiha reveal a strikingly high proportion of ventrally retouched implements (33% to 43% of all tools). In the Hummal Mousterian, ventral retouch is generally rare, but seems to be more frequent in the uppermost levels (chapter 6.11). Another idiosyncratic feature of the Tor Faraj and Tor Sabiha samples is the concentration of retouch on mesial and proximal point edge sections. It is conclusive to assume that this pattern reflects hafting facilities (Henry 1995a). Interestingly, we observed a reverse pattern in the Hummal assemblages in which the majority of points show retouch at the distal tip. This could be due to a differential use of points in both sites or differences in hafting technology; in this respect, it is possible that the access to natural bitumen usable as mastic in the El Kowm region reduced the need for proximal edge regulation.

The technological organization reflected in the two Jordanian rock-shelter sites corroborates observations that were made for the Hummal Mousterian (chapter 8). The fact that Tor Faraj, which is located far away from raw material, was provisioned with complete nodules and prepared cores, whereas the Tor Sabiha saw an import of blanks and low on-site core reduction, despite its proximity to raw material sources, corroborates our observation that provisioning strategies do not necessarily follow a distance-decay relationship (Henry 1995a, 1995b). It has been shown that the Mousterian occupants in Hummal applied variable strategies of raw material acquisition and use depending on the function of the site. Tor Sabiha probably served as a transitory camp; raw material procurement was rather embedded in other subsistence activities, and provisioning the site with stock was unnecessary. Contrastingly, Tor Faraj was a regularly visited, long-term encampment, and hence a wider range of activities required a considerable amount of raw material. Although the rock shelter is 17 to 22km away from suitable raw material sources, a targeted procurement and provisioning of place strategy, which necessitated the transportation of considerable loads, was applied. To economize on raw material use, core reduction was pushed to the extreme and many flakes were secondarily used as cores. The same behavioral pattern is observable in Hummal, and it is certainly no coincidence that the humans at Tor Faraj and Hummal had to cope with equal distances to raw material outcrops. Combining the evidence of both sites, the importance of the secondary flaking method can be seen as positively correlated to transport distance; a similar observation was made for Mousterian sites in the Central Negev (Munday 1976).

9.5 Conclusion

The comparison with Umm El Tlel, Yabroud, Kebara, Amud, Tor Faraj and Tor Sabiha shows that the techno-typological variability inherent in the Late Mousterian industries of Hummal clearly echo the complexity which characterizes this period in the Levant. Besides the complexity of technological organization patterns, variability in the Late Levantine Mousterian can be expressed by inter-assemblage and inter-site differences in core preparation and reduction methods, blades vs. flake proportions, and point morphologies (Fig.130).

Admittedly, the techno-typological variability of the Levantine Mousterian cannot be comprehensively described with these parameters alone. Nevertheless, the frequency distributions of Levallois blank categories in correlation with the significance of the unidirectional convergent flaking method only summarily reflect the basic characteristics of the Early, Middle and Late Mousterian complexes and the considerable variability within these groupings. Figure 130 clearly shows that so-called Tabun D industries are basically comparable to the Late Mousterian complex in terms of assemblage composition and Levallois point production. However, the majority of Early Mousterian samples reveal higher blade and/or point proportions than many of the Late Mousterian samples.[38] During the latest Mousterian phase, two major types of assemblages are discernible. The first is characterized by high blade and/or point proportions and a moderate-to-low importance of the convergent flaking method; examples are Hummal levels 5a2 to 5E, Yabroud KS 2 and Amud B2. Levallois point production in these levels is always accompanied by a second alternative flaking method to obtain blades or flakes. The second assemblage type is characterized by relatively high flake and point proportions and a predominance of convergent scar patterns on the dorsal face of cores and debitage; examples are Hummal level 5AII and 5AIV, the Kebara levels IX to XII, Amud B4 and B1, and Tor Faraj. It is important to stress that the proposition of two Late Mousterian clusters based on intra-assemblage variability should be seen as a working hypothesis for forthcoming studies of Middle Paleolithic variability in the Levant. Many more techno-typological parameters have to be considered, and adequate data is not to hand for a significant number of so-called Tabun B sites. One important aspect which can be deduced from Table 69 is that the more scanty our knowledge is of a certain artifact sample, the more careful we have to be with an assignment to any of the Mousterian phases.

Returning to the principal question of this chapter, it is reasonable to allocate the major part of the Hummal Mousterian sequence somewhere in the timeframe between 80ka and 50ka BP. The inter-site comparisons make clear that Hummal levels 5AI to 5E reveal idiosyncratic features, such as the marked laminar tendency in many levels, but also share many traits with other Late Mousterian sites in El Kowm and beyond. The allocation of the lowermost Hummal levels 5e to 5g to the Levantine Mousterian of Tabun C type is tentative. Provided that this assumption proves to be correct, a chronological placement of these levels into MIS 5 would be in agreement with the preliminary TL dating results for level 5g.

Current models for Mousterian settlement dynamics in the Levant suggest an increasing technological variability and subsistence intensification from ca. 120 kya. or MIS 5

[38] The attribution of Ksar Akil levels XXVIIIA and XXVIIIB to the Early or Late Mousterian is debatable. The present study follows the original interpretation of Marks & Volkman (1986).

onwards, probably due to a rising population pressure (Hovers 2001; Meignen et al. 2006). Assuming that Mousterian industries HM-A1 and HM-A2 fall into the chronological range of the Late Middle Paleolithic, this view can in part be corroborated by studying another site with evidence for numerous and recurring occupations relating to the existing picture of densely occupied locales during this period. While these models are mainly based upon cave sites, which by their nature represent a fixed, circumscribed spatial setting, the spring of Hummal is an example of an open-air site at which the constantly changing topography leads to a complex pattern of site-use through time. Reconstructing these settlement patterns is a delicate issue since the position of residential camps or task-specific localities was based upon the prevailing extension of the source and its surrounding features (chapter 8). In contrast to many cave sites, such as Kebara, Qafzeh or Amud, which were regularly and intensively occupied, the recurrent character of occupation is not coupled with one and the same function of the locality. The Hummal sequence rather gives the impression of an alternation between base camps and task-related localities with corresponding lithic assemblages reflecting different strategies of raw material procurement and consumption. This variability of site-use at a single spring suggests a complex Mousterian settlement pattern for the whole El Kowm region with its abundance of such water sources. The presence of many springs in a small area probably allowed hominids to select the best locales at any point in time, and therefore the positions of base camps could have shifted from source to source depending on the conditions at these locales, conditions which in turn were only partially controlled by climatic factors alone. Detailed archaeological investigation of the El Kowm region is still just beginning, and therefore it is not possible to present a general reconstruction of Mousterian settlement dynamics in this area. However, the complexity of site-use that is already visible in Hummal reflects a high degree of anticipation and flexibility among late Mousterian hominids. This aspect has also been proven at other Mousterian sites in the Levant within comparable or different environmental settings (Henry 1995a, 2003; Marks 1981, 1989; Marks and Freidel 1977; Meignen et al. 2006; Munday 1976; Shea 2007).

The laminar aspect of the majority of assemblages and the increasing focus on Levallois point production mirror an adaptive strategy that seems especially important in an arid steppe environment. It has been claimed that the production of elongated blanks allowed for a greater edge production efficiency, which in turn had a positive effect on portability (Henry 1989, 1995a; Kuhn 1994). However, a recent experimental study shows that this is not necessarily the case (Eren et al. 2008). Eren and colleagues demonstrate that the smaller a blank, the more efficient it is in terms of cutting edge per flake mass. This observation can be taken as an explanation of the abundance of cores on flakes showing minuscule flake removals. Thus, these pieces are not simply evidence of raw material recycling, but represent the remains of a targeted production aiming at small, easily portable implements with a maximum of cutting edge efficiency. It is possible that these pieces were removed from the site to be used at other localities, making it hard to recognize them in the Hummal assemblages. Portability is a crucial aspect in subsistence technologies, which center on a high level of mobility (Shott 1986). In this respect, an increasing standardization in blank morphology could have been advantageous in combination with greater reliability of the implements belonging to the transported tool kit. Although use-wear studies of Levallois points prove that these tools were multipurpose implements (Beyries and Plisson 1998), it can be assumed that the narrowing of blank production to Levallois points is the result of an emphasis on hunting (Henry 1995a; Lieberman & Shea 1994; Shea 2007). The technological homogeneity expressed through an exclusive use of the unidirectional-convergent flaking method in the upper HM-A1 industry is rather the indication of an increasing specialization on a single subsistence strategy than a material manifestation of group identity as is proposed by Hovers (2001). This is not to say that a common *savoir-faire* in the sense of a shared technological tradition had no influence, but standardization of point production in the Hummal Mousterian is better understood in terms of efficiency and tool utility. Therefore, the Mousterian assemblages of Hummal can be seen as products of highly mobile hunter-gatherers whose subsistence was based largely on the exploitation of large ungulates, such as camels, equids, and gazelles. However, the importance of vegetal resources should not be underestimated (Hovers 2001), especially in a region where the scarcity of such resources could have rendered them highly valuable. The correlation of high-density levels with soil formations attesting for a dense vegetation cover in the surroundings of the spring is an indirect indication of the importance of plants in the subsistence of Mousterian hunter-gatherers.

The lower industry HM-B with its scarcity of points and frequency of broad centripetally prepared Levallois flakes suggests a different technological strategy compared to the upper industries. Due to the scarcity of faunal remains, it is not possible to formulate any hypothesis about activities that were carried out during the older Mousterian occupations in Hummal. If the lithic material can in fact be correlated with a C-type Mousterian, prevailing assumptions about the distribution of this facies need to be altered. The existence of a Mousterian assemblage of the Tabun C type in the arid interior part of the Levant contradicts current theory, which states that the “broad oval” facies is a special adaptive response in the context of woodland areas in northern Israel, Lebanon and western Syria (Copeland 1981a; Henry 1995a; Lindly and Clark 2000). Further archaeological investigations both in Hummal and the surrounding El Kowm area will shed new light on previously mentioned issues and on additional questions in the current discourse about chronology, technology and evolutionary significance of the Levantine Mousterian.

A Catalogue: lithic assemblages

The following catalogue briefly describes the composition and major techno-typological characteristics of single Mousterian lithic assemblages found in Hummal. Assemblages 5b6, 5BI and 5BIII are not considered due to low sample size and the fact that artifacts recovered from the latter two levels during the 2008 and 2009 excavations have not been analyzed yet; the same holds true for archaeological complex 5F.

A.1 The western assemblages

A.1.1 Assemblage 5a1

(Fig.131)

A summary analysis of the lithic collection resulted in the count of 93 Levallois blanks, 7 non-Levallois blanks, and 9 retouched tools, the remainder being core trimming elements and fragments (Tab.9). Items below 2cm in size were not recovered during excavation and the sediments were not sieved. The flaked items are accompanied by 38 cores, among which reduced flake cores and cores on flake predominate.

Large Levallois points with a broad base and markedly bent dorsal negatives are noticeable among the blanks. (Fig.131, Nr.1, 2, 4). Next to these large pieces, many small Levallois points and flakes with a size between 2 and 3cm occur, indicating that these blanks were produced all along the reduction sequence (Fig.131, Nr.3). This observation is matched by the small size of Levallois cores and simple flake cores with a mean surface size of 5x5cm and a mean thickness of 2.5cm. The majority of Levallois cores were exploited in an opportunistic manner, ending as flake cores with unidirectionally, bidirectionally and semi-centripetal scar patterns. Recycling of broken flakes and tools is evidenced by the frequency of cores on flakes, among which the majority show carefully prepared striking platforms and an exploitation of the dorsal surface with one or two removals. The presence of three prismatic blades, including a crested blade, and one conically shaped blade core, reinforces the mixed appearance of assemblage 5a1. The blades are not sufficiently diagnostic to warrant a decision as to whether they are of Upper Paleolithic or Mousterian age.

A.1.2 Assemblage 5a2

(Fig.132)

Assemblage 5a2 mirrors a technology which shows a clear differentiation between Levallois point production on one hand, and Levallois blade and flake production on the other. Despite an intrinsic correlation of these end-products within the unidirectional convergent Levallois method, many blades and flakes with unidirectional scar patterns stem from a separate reduction process aiming at non-triangular blanks. Levallois blank production is paralleled by a secondary production of flakes from waste flakes and debris. Direct evidence for this opportunistic raw material exploitation is given by cores on flakes and Kombewa flakes. Two flakes and one chopping tool testify to the use of silicified limestone for either flake production or the fabrication of core tools.

The 1631 artifacts found in level 5a2 are the remainder of an intensive on-site core reduction. This explains the high percentages of core trimming elements and small lithic debris, which account for more than 60% of the total assemblage (Tab.9). Among the cortical flakes, one-third exhibit a weathered surface or neocortex and are thus evidence of the procurement of raw material in secondary outcrops, probably in dry valleys near the site (Fig.132, Nr.7). The mean size measured for cortical flakes is 3.8 x 2.9cm and the majority have a surface size of 20cm^2 or below. The scarcity of large cortical flakes and the absence of first flakes suggest that on-site Levallois blank production involved already prepared cores (chapter 8). Table 9 shows that all typical by-products of Levallois blank production are present. About one-third of the core edge flakes and 40% of the flaking surface flakes accumulated in the course of Levallois point production. The decisive attributes for this interpretation is their twisted longitudinal axis, dorsal scar pattern and offset striking axis. Among Levallois blades and flakes, items bearing these traits are rare, and it is therefore safe to argue that they are not by-products of point production, but rather represent alternative end-products. The majority of Levallois blades and flakes exhibit polygonal outlines and unidirectional-parallel scar patterns. Most of the Levallois points are of the classical type, showing three negatives and the Y-scar pattern on their dorsal surface, and a pronounced *chapeau de gendarme* and faceted butt. With a mean length-width ratio of 1.7, the Levallois points of level 5a2 are relatively short compared to underlying assemblages. However, the size range is large, as they were produced throughout the reduction sequence. The same holds true for flakes and blades, and 10cm-long specimens are found next to small ones with a size of 3cm or below (Fig.132). As in other Mousterian assemblages at Hummal, Levallois and non-Levallois waste cores are scarce, but their size is remarkably large compared to other levels. Their length varies between 7 and 8cm and the width between 5 and 7cm respectively, except for two extremely reduced pieces, of which one exhibits bladelet removals before discard. Hinge fractures were a common reason for abandoning the cores. A few cores exhibit traces of a recurrent Levallois blank production (Fig.132, Nr.9). Some specimens show a secondary opposed striking platform which did not serve for blank production but for the preparation of the distal convexity and/or correction of hinge fractures.

Usage of complete or fragmented flakes for a secondary production of small flakes and bladelets on their dorsal surface seems to have been a common behavior regarding raw material exploitation. The blanks removed are usually 2 to 3cm large and are hardly distinguishable from core trimming flakes. This explains the paucity of entries in the non-Levallois blank group (Tab.9). Only three cores on flakes reveal a production of small blanks on their ventral surface. Eight corresponding Kombewa flakes were found and their small mean size of 3 x 3cm indicates that the Kombewa method was not applied to large flakes. It is interesting to note that even a tertiary flake production is evidenced by a core on a flake that was made on a former Kombewa flake. This piece exemplifies the exhaustive exploitation of raw material and the intention to obtain tiny flakes smaller than 2cm.

A.1.3 Assemblage 5a3

(Fig.133 and Fig.134)

According to its assemblage composition and artifact density, level 5a3 mirrors a relatively long occupation span during which a significant need for raw material was given. The site was provisioned with flint from primary and secondary outcrops and the occupants applied a targeted raw material procurement strategy. At remote flint outcrops, decortication and subsequent stages of core preparation took place. Blanks, prepared cores as well as unmodified flint nodules were then transported to Hummal (chapter 8). Analysis of the flakes and cores reveals that elongated Levallois blanks were desired end-products (Fig.133). Recurrent blank production delivered points, triangular-shaped flakes as well as regular blades during the earlier stages of core reduction. Later, quadrangular flakes and small Levallois points came into focus. Many cores on flakes testify to a secondary reduction sequence during which flakes and tools were systematically recycled. Flake production on flint was accompanied by a sporadic shaping of limestone into choppers and chopping tools.

Probably a few raw material blocks have been reduced from their initial state into small, exhausted cores in a coherent sequence at Hummal. Typical preparation products such as first flakes or cortical flakes relating to the first core trimming stage are present, although in rather low numbers (Tab.9). Only two first flakes represent the initiation of a nodule. One of them is covered by neocortex showing traces of rolling. Thus, it is direct evidence of the collection of flint cobbles in alluvial fans. Subsequent cortical flakes constitute not more than 14% of all core trimming elements. Only four pieces show a length of more than 7cm, and can therefore be attributed to initial core shaping. Regarding all cortical flakes together, their low mean length of 4.7cm and rather elevated mean width of 3.9 cm indicate that most of them were not produced during the creation of an initial flaking surface but during later stages of the reduction sequence. On their dorsal surface they normally present one or two parallel negatives and the cortical area is frequently found in the distal half. These second or third order cortical flakes are remnants of an enlargement of the flaking surface. Most of them are probably related to the opening of new flaking surfaces after the depletion of others. As some flint nodules exhibit a usable sub-cortical zone, it is not clear whether decortication had to be done at all.

Huge core tablets and cortically backed knives are related to the maintenance of the flaking surface in the first stage of production (Fig.133, Nr.1). Levallois blanks in the range of 5 to 8cm were then obtained. The removal of the two core tablets aimed at a total reorganization of the flaking surface after the production of Levallois points. The backed knives are thick blades and their large size indicates that they are by-products of early stage Levallois blade and point production .

After the initial production stage, whereby most of the cortical areas have been cleared away, the naturally backed knives are replaced by core edge flakes and blades which exhibit parts of the prepared core edge on their lateral parts (Fig.133, Nr.2, 3). They accompanied Levallois blank production at all stages, the smallest such flake being 3 cm long. After a centripetal preparation of the flaking surface, the *débordant* flakes initialized the recurrent unidirectional Levallois blank production by creating the necessary lateral convexity. Most of the 15 *débordant* flakes initialized Levallois point production.

A significant part of core trimming flakes in assemblage 5a3 is related to the reorganization of the flaking surface after each series of blank production. These flaking surface flakes are the most frequent determinable core trimming elements in level 5a3. They were struck from around the core’s circumference with the help of prepared supplementary striking platforms, as is evidenced by faceted butts visible on the majority of these flakes. As volume loss on the surface was held low and preparation was done from multiple directions on the flaking surface, these flakes are small with a mean size of 5 x 3cm. Sporadically, they were modified into tools, given that they exhibit a suitable morphology (Fig.134, Nr.1).

Levallois blanks account for 25% of all flaked items. Elongation is a characteristic attribute of all blank types found in layer 5a3 (Tab.18 and Tab.22). The length-width ratio distribution among blank categories shows that median values tend towards the blade limit at

2.0, whereby the median for points and flakes is found at 1.9 and 1.7 respectively. This laminar aspect closely correlates with the fact that most blanks were struck from one and the same faceted striking platform during the entire core reduction sequence (Tab.19). The dorsal scar patterns are predominantly of the unidirectional-parallel (41%) or unidirectional-convergent type (46%). A few Levallois blades exhibit a perpendicular pattern and indicate a 90° rotation of the core during reduction. Although a certain proportion of blades and flakes can be seen as by-products of Levallois point production or as potential "misshits" in the sense that their morphology deviates from the classical point type, it is safe to assume that blades and flakes were deliberately produced as end-products on the basis of their symmetry and position on the core's flaking surface. Thus, Levallois core reduction followed two principal objectives which were realized within the same *chaîne opératoire*:

1) production of Levallois points with typical attributes like the *chapeau de gendarme*, greatest width at the base, Concorde-shaped distal profile and Y-like scar pattern (Fig.133, Nr.8, 11, 15).
2) production of blades and flakes with a triangular or rectangular form in the early core reduction stage, and quadrangular, rounded or polygonal forms in the later phase (Fig.133, Nr.4-6, 9-10, 12-14, 16).

These morphological features together with a predominance of concave-convex or straight-convex edge profiles correlate with acute edge angles clustering around 30°. The majority of Levallois points can be considered as "classical", exhibiting three anterior converging removals. A few specimens exhibit more than three negatives coming from the same or a perpendicular direction. Short, broad-based examples are rare, and a clear tendency for elongation is visible. An interesting case is a Levallois point produced in a Kombewa-like manner. Small cortical residues on its distal tip suggest that the point was struck from a big cortical flake with a length of 6cm. Two previous removals were true Kombewa flakes, which probably had a trimming function in order to create the triangular scar pattern.

Levallois cores falling out at an early stage of production are absent. Only four items exhibit distinctive Levallois features which are not blurred by final reduction methods. With a size of around 6 x 6cm, they are waste cores with an insufficient volume for further Levallois blank production. Between 70 and 100% of their lower side is covered with cortex. With 4 to 5 removals extending into the cortical zone, the striking platform, which never extended around the whole circumference, was maintained. Before each series of Levallois blank production, the area around the percussion point was carefully faceted. The scar pattern on the cores shows that the unidirectional and convergent flaking method was pursued until the end. Two specimens evidence that the ultimate production stage saw a halt to recurrent flaking and a shift to preferential blank production. This is accompanied by a careful semi-centripetal preparation, and left-over cores show up to 6 respective removals. The flexibility of the recurrent Levallois concept in respect to the morphology of raw material blocks is nicely illustrated by a core on a flake on which an atypical Levallois point was refitted (Fig.72). The proximal fragment of a huge Levallois flake served as a core without any elaborate preparation. The knapper just prepared the breaking surface to get a flaking angle of around 80° and then exploited the fragment intensively on its ventral surface (7 removals). One of the last removals was the mentioned Levallois point measuring 4.5 x 2.1 cm.

Ten blades and two flakes were assigned to the group of non-Levallois blanks. Their low number does not allow any specification of the flaking method. Furthermore, their interpretation went not without problems as some can potentially be seen as core trimming flakes which accidentally received a symmetrical form. Crucial attributes for their designation as non-Levallois blanks are an unprepared butt, an irregular scar pattern and the orientation of the blow along a single prominent ridge. The non-Levallois blades are small, with a mean size of 6 x 2cm. The smallest ones could stem from a secondary exploitation of flakes as cores aiming at the production of bladelets. Two flake cores represent the opportunistic removal of blanks after the Levallois method was no longer applicable. With a size of around 2.5cm, they are extremely small and therefore represent the ultimate stage of production.

The most frequent core types found in level 5a3 are cores on flakes, which account for 64% of all cores. Out of 14 pieces, 8 flakes were reused on their dorsal face, 4 on their ventral face and 2 on both. Frequently, the dorsal face of broken flakes served for a secondary blank production (Fig.133, Nr.17). In each case, faceted striking platforms were created on the breaking surface to obtain striking angles between 50 and 80°. Apart from three Kombewa flakes and the mentioned Levallois point produced on the ventral surface of a flake, no other artifacts are referable with certainty to this secondary reduction.

The 24 retouched blanks account for 10% of the flaked assemblage. Retouched tools were principally manufactured on Levallois blanks (80%). The majority are partially retouched blanks, convergent side scrapers or Mousterian points (Fig.134). Partial retouch was frequently applied in order to regularize one or both edges of a blank, an intention which is nicely shown by retouched Levallois points being “corrected” in this manner. In some instances retouch is found together with macroscopic use-wear traces, making a clear recognition of intentional edge modification problematic. Mousterian points are represented by beautiful items which exhibit a perfect symmetry and edge shape. Less frequent are side scrapers with a convex or straight working edge.

Two core tools evidence the use of limestone blocks for certain activities. One of them is a chopping tool-like tool fabricated on a homogeneous limestone slab. It weighs 660g and measures 13.6 x 11.1cm with a thickness of 3.5cm. The five alternating negatives are found on one longitudinal edge. For the moment it is not yet clear whether this object is actually a tool or a core. The latter designation is equally plausible as two limestone flake fragments were found in level 5a3. The second core tool was fabricated on a small limestone slab. It shows a coarse but continuous retouch on one edge and considering its overall shape the piece resembles a *Keilmesser*. The tool measures 12.7 x 5.3cm and is remarkably thin with a thickness of 1.8cm.

A.1.4 Assemblage 5a4

(Fig.135)

Over two-thirds of the excavated artifacts are lithic debris smaller than 2cm (Tab.9). Their significant quantity suggests that core reduction and tool manufacture were principally carried out at Hummal. Furthermore, core trimming elements related to all stages of core reduction are present. Most of the cortical flakes and core edge flakes are large, with a mean size of 6 x 3cm, the largest pieces being 11cm long. This indicates that core reduction began at a relatively early stage. A major characteristic of level 5a4 is the laminar morphology of many Levallois blanks (Tab.18, Tab.22 and Fig.135). The mean mean length-width ratio of Levallois blades is 2.9, and seven out of nine Levallois points fall into the laminar category with a corresponding value of 2.4. Although sample size is small, two separate goals of core reduction can be reconstructed. On the one hand, rectangular and polyhedral shaped blades and flakes were obtained by recurrent unidirectional-parallel flaking; on the other hand, elongated Levallois points were produced on cores with a unidirectional-convergent scar pattern.

Except for one Levallois point core, the five exhausted nodule cores found in level 5a4 do not reflect the mentioned flaking methods (Fig.135, Nr.5, 11). Having an average size of 4 x 4cm, three out of four were intensively exploited by unidirectional removals shortly before their discard. The smallest one weighs 8g and has a length of 3cm, a width of 2.1cm, and a thickness of 1.5cm. It is the smallest flake core found in all the Mousterian assemblages so far. Cores on flakes are equally rare and the three pieces found exhibit two or three small blank removals on the dorsal face of former flakes.

Elongated Levallois points and blades were the preferred end-products to be transformed into retouched implements. The dominant types are side scrapers, double scrapers, and partially retouched Levallois blanks (Fig. 135, Nr.6-10, 12). Assemblage 5a4 is one of the rare cases in Hummal in which denticulates made on Levallois blanks are found.

A.1.5 Assemblage 5b1

(Fig.136)

Level 5b1 contained only a small archaeological sample consisting of 363 lithic artifacts. Although the low sample size hampers a detailed technological analysis, some general aspects are nevertheless discernible. Small debris with a size below 2cm comprises nearly two-thirds of the total assemblage and it can therefore be assumed that core reduction and tool manufacture were principally carried out on-site. This assumption is corroborated by the mean size values of preparation flakes. Two out of four cortical flakes are more than 7cm long, and the six flaking surface flakes show a mean length value of 7.5cm. Regarding the Levallois blanks, it is striking that no point was identifiable as such, although the dorsal scar pattern visible on the blanks is frequently of the unidirectional-convergent type and about half of the flakes and blades exhibit a pointed distal tip. It is possible that Levallois points were in fact the aim of core reduction and were later exported to other localities. Apart from Levallois points, large blades were produced in the early stage of blank production using one striking platform. In the later stage of reduction, they were replaced by quadrangular Levallois flakes. Among the flaked tools, only three side scrapers and three convergent scrapers show an extended retouch (Fig.136, Nr.2, 7). A nice example for the recycling of flakes taken from the waste of earlier occupations is a single straight-side scraper made on a flake that exhibits an intensive white patination (Fig.136, Nr.4). The remaining tool group consists of one partially retouched Levallois flake and two atypical burins, showing a distal truncation from which bladelet removals were struck along one lateral edge. It is unclear whether these pieces are actually burins or cores on flakes.

Among the cores, one flake core is a silicified limestone from which flakes were struck in an alternating fashion. Additionally, four cores on flakes were identified which are all made on flake fragments of which either the dorsal (one specimen) or the ventral surface (three specimens) served for blank production. An exceptional artifact found in level 5b1 is a large chopping tool made on a tabular limestone block (Fig.136, Nr.1). The piece weighs more than 2kg and is the largest chopping tool excavated so far. Sharp working edges were formed with more than 20 alternating negatives. The chopping tool was not classified as a core because of macroscopic use-wear visible on parts of the working edge.

A.1.6 Assemblage 5b2

(Fig.137)

Apart from much small lithic debris, which accounts for 78% of the total assemblage, Levallois blanks are present in significant numbers (Tab.9). The largest specimens as well as successively resharpened Mousterian points were probably introduced as imports (Fig.137, Nr.7, 8); however, the majority of Levallois blanks stem from on-the-site core reduction. The scarcity of cortical flakes and the small mean size of core trimming flakes indicate that already prepared cores were transported to Hummal. Core reduction was focused on Levallois point and flake production. Both blank types show a considerable size range involving elongated Levallois points and large polyhedral-shaped flakes with a length over 10cm; next to these large-sized blanks, tiny points and flakes with a size below 3cm occur (Fig.137, Nr.3). The tool spectrum is dominated by side scrapers and Mousterian points. Two burins are grouped in the Upper Paleolithic tool type category. One of them, showing the removal of a spall at the right lateral edge of a twisted core trimming blade (Fig.137, Nr.5), can be considered typical.

As in many other Mousterian levels of Hummal, the majority of cores in level 5b2 are remnants of a secondary non-Levallois blank production made on flakes. Only one nodule core is a waste core stemming from the production of Levallois points. The two flake cores are small exhausted specimens which exhibit opportunistic flake removals on their flaking surface (Fig.137, Nr.2).

A.1.7 Assemblage 5b3

(Fig.138, Fig.139 and Fig.140)

The basic characteristics of assemblage 5b3 indicate that the sample is homogeneous in several respects. Most artifacts (96.3%) were made on Lower Eocene flint and exhibit a light orange-brown patina which is caused by iron-oxide precipitation. Only a few black-colored pieces which account for not more than 0.4% of the total assemblage probably stem from overlying deposits and were vertically displaced along fissures or mixed with level 5b3 in the transitional zone between the Pleistocene deposit and the modern well infill. Edge-damaged artifacts are rare; however, in many instances it is difficult to distinguish actual damage from use wear. The high proportion of lithic debris smaller than 2cm and the systematic presence of core trimming products suggest that many blanks were produced on the spot (Tab.9). The low number of cores and their small average size of 5 x 4cm indicate that core reduction was pushed to the extreme. The primary blank production was accompanied by a secondary removal of small blanks from large flakes or fragments. Yet this recycling strategy seems to have been less important compared to other levels (Tab.15).

Some core reduction sequences, including nodule decortication and the shaping of a future flaking surface, started at an early stage. First flakes and a few large cortical flakes testify to this procedure (Fig.139, Nr.1, 2). The majority of cores, however, were presumably prepared at raw material procurement localities and later imported into Hummal. The size of these cores must have been at least 8cm, an assumption which is based on the mean size values of core trimming elements and the position of the 75th percentile of median length for Levallois blanks (Tab.48). Levallois blank production was performed until the volume of the core was too low for a perpetuation of the necessary morphometric structure. In the latest phase of core reduction small points and flakes with a size between two and three centimeters were obtained, accompanied by core edge flakes and flaking surface flakes in the same size range. Levallois points were the focus of production throughout the reduction sequence. Many classical Levallois points with three dorsal negatives and a pronounced *chapeau de gendarme* are found next to atypical points (more than three dorsal negatives, irregular morphology) and many triangular flakes and blades (Fig.138 and Fig.139). Although frequent, Levallois blades seemingly played a minor role, as some of them are by-products of point production and their overall elongation is low compared to other levels; the median LWR of Levallois blades in level 5b3 is 2.4, compared to 2.8 in level 5a4. Contrastingly, the flakes seem to have been a desired end-product, especially in the later stages of core reduction when small, quadrangular pieces were produced (Fig.139, Nr.6).

The principal core reduction concept involved the recurrent unidirectional parallel and unidirectional convergent method. Striking platforms were systematically faceted. A few flakes (n = 4) and one point exhibit centripetally arranged negatives on their dorsal face (Fig.139, Nr.8). They were struck from large flaking surfaces and represent the first blanks obtained in a series of blank removals during the early stage of core reduction. Hence, they lack any negatives of anterior blank removals on their dorsal surface[39]. In the later stage of core reduction the centripetal preparation of the flaking surface was no longer applied; the lateral and distal convexities were then created by core edge flakes, perpendicular removals and/or small flaking surface flakes struck from the opposite direction (Fig.138, Nr.6; Fig.139, Nr.5; Fig.140, Nr.10). For this purpose, supplementary striking platforms were created on some parts of the core edge or around its total circumference. The perpetuation of the

[39] The technological significance of this type of Levallois flake was identified by Boëda in his study of the recurrent Levallois concept (Boëda 1994, 1995). He designates the initiating Levallois blank as *enlèvement I* or “Levallois blank type 1” and distinguishes it from the following flakes which show one or more blank negatives on their dorsal surface. Although type 1 Levallois blanks can also be obtained by the preferential Levallois concept, it is safe to assume in the case of level 5b3 that they were in fact the starting flakes of a recurrent series, because the subsequent blank types are found as well (e.g. Fig.138, Nr.5, 7, 9).

unidirectional flaking method until core exhaustion is reflected by the dominance of unidirectional parallel scar patterns visible on Levallois cores and flake cores. The structural hierarchy between the flaking surface and the lower side of the core did not change throughout the reduction sequence. Only three waste cores evidence the use of two flaking surfaces, which were exploited at the same time or one after the other. Level 5b3 is one of the few assemblages in which nodule cores are more frequent than cores on flakes. The latter comprise mainly flake fragments that were exploited on their dorsal surface. Two Kombewa cores evidence the potential of thick cortical flakes for a secondary blank production; only two respective Kombewa flakes were identified (Fig.139, Nr.10).

The fact that 26% of all artifacts larger than 2cm show macroscopic use wear on their edges reveals the importance of flakes with sharp cutting angles that were ready for immediate use without further modification. Among Levallois blanks, every second piece exhibits traces of use, and a significant proportion of Levallois fragments further corroborate the *ad hoc* use of these end-products. Admittedly, these frequencies have to be affirmed by a microscopic use-wear analysis and differentiated from edge damage caused by natural forces, but an expedient use of sharp-edged flakes seems to have been the principal aim of core exploitation. The proportion of retouched tools is low in level 5b3, with only 43 implements accounting for 10% of the total assemblage, excluding small debris. In addition, only partially retouched blanks are the dominant tool type, corroborating the importance of unmodified working edges of which a small part had to be rectified in some instances (Fig.140, Nr.2, 9, 11). Retouch was sometimes applied to the blanks' ventral surface, probably with the aim of creating a more robust working edge (Fig.140, Nr.6). A rare type is the alternate retouched side scraper, of which only two more specimens were found in other Mousterian levels (Fig.139, Nr.12). Assemblage 5b3 contains only six double scrapers and Mousterian points (Fig.139, Nr.7, 8); side scrapers are strikingly scarce compared to other levels; one of them has a Yabrudian type of invasive retouch and represents a scraper type which is atypical in the Hummal Mousterian (Fig.140, Nr.3). Among the double scrapers we found an elongated tool bearing traces of small flake removals in its proximal part that removed the bulbar area (Fig.140, Nr.8). The thinning is so regularly executed that this scraper can be seen as a nice example of a tool with a hafting device. Apart from a few notched pieces and denticulates, we found two blades with an end-retouch and grouped them in the Upper Paleolithic tool category (Fig.139, Nr.13 and Fig.140, Nr.11).

A.1.8 Assemblage 5b4

(Fig.141)

The lithic assemblage consists of 26 complete flakes and 13 fragments with a size of over 2cm and 20 small chunks (Tab.9). Given the small sample size, a reconstruction of technological behavior is not possible. The major part of assemblage 5b4 is made up of core trimming elements and flake fragments; no core has been found yet. The Levallois blanks are similar to their counterparts in over- and underlying levels. Worth mentioning is the presence of elongated Levallois points (Fig.141, Nr.1). Four pieces were identified as retouched tools: two notched pieces, one fragment with retouch on the ventral surface, and one atypical burin (Fig.141, Nr.2).

A.1.9 Assemblage 5b5

(Fig.142 and Fig.143)

Assemblage 5b5 contains 1206 artifacts which were retrieved from the surface excavation in 2006 and the two test pits W1 and W3 (Tab.9). Only the excavation sample was taken for a detailed technological analysis. The large amount of small lithic debris can be taken as a positive sign in respect of the assemblage's integrity and excludes the sorting of objects according to their size. The bulk of end-products were made on Lower Eocene flint cobbles (92.2%), whereas the Cretaceous flint variety, limestone and travertine were used to a marginal extent. A small Levallois-like flake made of limestone evidences the technical potential of this material, provided that the block had a homogeneous texture (Fig.142, Nr.17). A significant amount of relatively small flint cobbles were collected from secondary outcrops and reduced in Hummal. They were probably selected according to their natural morphology, in the sense that well-rounded cobbles enabled the knapper to spare laborious preparation. This aspect is nicely illustrated by a Levallois point core made on a small, weathered cobble (Fig.59, Nr.5).

Many if not all Levallois blanks were presumably produced on the spot, an assumption that is based on the presence of cortical flakes and other typical by-products of the Levallois method (Tab.9). Levallois points seem to have played a less important role as their frequency among the blanks is relatively low (12%) in comparison to many overlying levels. Most frequent are quadrangular, triangular or polyhedral-shaped Levallois flakes and blades exhibiting unidirectional-parallel scar patterns on their dorsal surface (Fig.142). Some of the blades are markedly thin and the most elongated have an LWR around 5.0. In respect to the mean size of Levallois blanks and core trimming elements, level 5b5 is a singular case as the blanks are smaller than in every other level (Fig.62 and Fig.64). Core reduction was pushed to the extreme, delivering flakes and small bladelets with a length of around 2cm in the final stage (Fig.142, Nr.13-15). One of the four Levallois cores found in assemblage 5b5 is evidence of the use of the preferential Levallois method to obtain the last flake (Fig.143, Nr.7). The artifacts' small size seems to be intrinsically correlated with the low volume of procured flint cobbles. Given that many more small cobbles compared to larger pieces have to be collected to be able to obtain a certain number of end-products, the scarcity of nodule cores is surprising (Tab.15). Striking are three exhausted non-Levallois blade cores with a (semi-) prismatic shape. They exhibit parallel blade removals struck from a single unfaceted striking platform (Fig.143, Nr.3). It can be assumed that prominent central ridges served as guides for the blow propagation; however, the technique is difficult to reconstruct, as corresponding blades were not found in assemblage 5b5. Another non-Levallois method of blank production is reflected by a considerable number of Kombewa flakes, Janus flakes and cores on flakes (Fig.142, Nr.18 and Fig.143, Nr.2, 4, 6). Some large Janus flakes, the largest having a length of 8cm, indicate the recurrent exploitation of parent flakes with a considerable size (Fig.143, Nr. 1). The intensity of flake exploitation is variable, with some cores on flakes showing only one or two negatives, next to others on which multiple removals from different directions are visible. As in level 5a3, large flake fragments served for Levallois blank production (Fig.143, Nr.2).

Retouched tools are extremely rare in level 5b5. Intriguing is the fact that only one convergent scraper is present. Is this another consequence of the small size of Levallois blanks hampering edge-consuming modifications? In the tool group we identified three notched pieces, one denticulate, an atypical burin and a few partially retouched Levallois blanks (Fig.142, Nr.19, 21).

A.1.10 Assemblage 5b7

(Fig.144)

Technological analysis of assemblage 5b7 is restricted to the sample recovered in trench W1. Some more artifacts, which probably belong to the same level, were retrieved in test pit W3. However, as the W3 sample's provenience is not without doubts, it was excluded from further analysis. Due to time constraints, lithic analysis was carried out rapidly and only major features, such as patination, damage and artifact type as well as basic metrics were recorded. The composition of assemblage 5b7 resembles overlying levels. Worthy of note is the high percentage (76.8%) of small debris and larger fragments (11%). It is likely that the blank group shows the usual predominance of Levallois types. Most of them were presumably produced at the site, as is evidenced by the presence of cores, cortical flakes and the high density of small core reduction by-products. Although the sample size is small, level 5b7 can be considered a laminar Levallois assemblage on the basis of high LWR means (Tab.18 and Tab.22).

Elongation is coupled with a remarkable thinness of all blank types, which suggests a very efficient exploitation of the flaking surface and high craftsmanship (Tab.21 and Tab.22). In the group of modified tools (n=8) two rare types are found. The first is a typical dihedral burin which exhibits a thinned base (Fig.144, Nr.1). The spatial relation between the active part and the thinning as well as the latter's fineness suggest that the burin was hafted. The second is the sole example of a retouched Kombewa flake in the Hummal Mousterian (Fig.144, Nr.2).

A.1.11 Assemblages 5c & 5d

The low sample size of both assemblages does not warrant any detailed techno-typological description (Tab.9). Furthermore, no information about the depositional context is available. Because of the discovery of two elongated Levallois points and the lack of flakes with bidirectional or convergent scar patterns in 5d, both levels were tentatively attributed to the HM-A2 complex.

A.1.12 Assemblages 5e & 5f

Level 5e delivered a small but interesting sample. The first aspect which immediately attracts attention is the intensive light grey-to-white-colored patination visible on all artifacts, which clearly separates layer 5e from overlying assemblages. Cores, core trimming elements and a high proportion of small debris are remains of a core reduction process for which only Lower Eocene flint was used, and which was carried out at on-site (Tab.9). 5e is one of the rare levels in which a preferential Levallois core was found (Fig.145, Nr.2). This piece and the presence of large, centripetally prepared blanks suggest a non-recurrent production of Levallois flakes and blades throughout the reduction sequence. Other blanks exhibit overlapping negatives on their dorsal face and are thus related to a recurrent production using one or two opposed striking platforms (Fig.145, Nr.1). As in many other Mousterian levels of Hummal, a secondary flake production is evidenced by two cores on flakes, of which one is a nice example of the so-called *Nahr Ibrahim* type (Fig.145, Nr.3).

Due to low sample size, the 5f assemblages are described together. As in level 5e, the artifacts exhibit a light grey-to-white-colored patination and were exclusively made of Lower Eocene flint. Assemblages 5f1 and 5f2 include a high proportion of small debris; however, only the former seems to reflect on-site core reduction, which is evidenced by all sorts of core trimming elements (Tab.9). Contrastingly, assemblage 5f2 is dominated by blanks and retouched implements, which account for 60% of the total assemblage (small debris excluded). Levallois blank production was obviously oriented towards large and thick blades, as well as quadrangular flakes (Fig.145, Nr.4, 5, 6, 7, 9). Their dorsal scar patterns show that reduction followed either a recurrent uni- or bidirectional concept, or a non-recurrent concept involving the centripetal preparation of cores. Levallois points as well as the convergent mode of reduction are scarcely found. The core group contains four cores on flakes of which three were identified as Kombewa-types and one as a secondarily exploited scraper fragment. Although sample size prohibits any definite statement, it seems that the quantity of retouched tools is higher compared to overlying levels. Partially retouched Levallois blanks were found next to intensively reduced specimens, which underwent several phases of resharpening (Fig.145, Nr.8).

A.1.13 Assemblage 5g

The lithic assemblage derived from layer 5g represents a palimpsest of waste from several site frequentations. The artifacts exhibit traces of the deposit’s significant reworking, such as battered edges and ferruginous coatings. Therefore, it is of limited informative value as regards the *chaîne opératoire* of blank production, reconstruction of technological organization and site-use. Technological analysis is hampered by the fact that 32 of 48 flakes larger than 2cm are fragments. Nevertheless, the deducible technological features show that the lithic sample belongs to the Lower Mousterian Industry HM-B in a techno-typological sense. Significant is the presence of large and relatively thick Levallois blades and flakes, many of which exhibit bidirectional or unidirectional scar patterns. It is possible that the production of elongated Levallois points played a more important role compared to overlying assemblages 5f and 5e, as a few blades and fragments with convergent scar patterns and at least one Levallois point were identified. Evidence for a centripetal exploitation of the flaking surface is given by the scar pattern of some core edge flakes and Levallois flakes. Although the sample is small, a significant diversity of core reduction strategies, which is typical for the HM-B industry, can be reconstructed. About the half of the unbroken debitage sample is made up of core trimming elements, including first flakes and cortical flakes. Their presence suggests that at least a part of the Levallois blanks was produced in Hummal. Unfortunately, no core has yet been found in level 5g.

A.2 The southern assemblages

A.2.1 Assemblage 5AI

The 5AI sample consists of 41 small debris and only 4 larger pieces of which 2 are non-diagnostic fragments. Only one *débordant* Levallois blade with convergent scar pattern and a relatively large Levallois blade core (10 x 8cm) were identifiable. Thus, assemblage 5AI is too small to be informative.

A.2.2 Assemblage 5AII

(Fig.146)

A characteristic feature of level 5AII are broad-based, elongated Levallois points which exhibit strongly converging or perpendicular scar patterns on their dorsal face (Fig.146, Nr.3-7, 10-11). The point sample of assemblage 5AII shows a higher mean number of dorsal negatives (5) compared to underlying levels. As has been shown in chapter 6, the core reduction strategy involved a recurrent removal of narrow, overlapping points and a final, large-sized point in each production stage. The strong longitudinal curvature which is visible on some blanks as well as the marked central ridge on their dorsal face indicate the preparation of flaking surfaces with a pronounced convexity. A faceted striking platform was prepared around the core’s circumference, and hence, all blanks exhibit faceted platforms (IF = 100). The majority of points and flakes show a *chapeau de gendarme* and relatively thick butts. The significance of Levallois point production is also inferred from the high number of triangular flakes and blades and the fact the 40.6% of all blanks exhibit a unidirectional convergent scar pattern (Fig.146, Nr.2, 8-9). The larger points and blades presumably belonged to the imported raw material package, whereas blanks in the smaller size range were rather produced on-site. Elongated core edge flakes with a length up to 8cm attest to the lateral preparation of recurrent Levallois point and blade cores. Waste cores are rare in assemblage 5AII, being represented by only two cores on flakes and one refitted Levallois point core (Fig.146, Nr.7, 12).

The majority of blanks were presumably utilized in an unmodified state, which is reflected by the low percentage of 9.7% of retouched tools among the debitage. The typological Levallois index is 0.0, and retouch is mostly restricted to a limited part of the flake edge. A characteristic tool in the small group or partially retouched Levallois flakes (type n° 106) are points with retouch on their ventral face (Fig.146, Nr.10, 11).

A.2.3 Assemblage 5AIII

Although the sample of complete flakes and cores larger than 2cm is small (n=18), the technological features visible on the blanks show that level 5AIII belongs to the point-dominated HM-A1 industry of Hummal. Worthy of note is the predominance of unidirectional convergent scar patterns and faceted platforms of the *chapeau de gendarme* type. The relatively high number of cores (n=4) and small debris (n=56) compared to flakes suggests that the latter were produced in Hummal on already significantly reduced cores; early stage preparation flakes are absent. The sample is too small to give insight into the technology of core reduction and tool use. It contains a nice example of a tool type, the side scraper on a ventral face, which seems to increase in importance in the uppermost Mousterian levels (Fig.100, Nr.9).

A.2.4 Assemblage 5AIV

(Fig.147)

Level 5AIV delivered the richest lithic sample so far attributable to the HM-A1 industry. Technological analysis has shown that the majority of large-sized Levallois points and flakes were introduced into Hummal as imports. On-site core reduction for which flint pebbles from nearby alluvial deposits were collected occurred to a minor degree. It is possible that at times, the scarcity of exploitable raw material units forced the knappers to re-use Levallois blanks or tool fragments for a secondary flake production. This is evidenced by the high number of cores on flakes, which account for 64% of all cores (Fig.147, Nr.13-14).

Levallois core reduction followed a standardized scheme that involved a systematic faceting of striking platforms around the cores' circumference and the creation of a *chapeau de gendarme*. From the prepared striking platform, the flaking surface was prepared with strongly converging or perpendicular removals, sometimes approaching a semi-centripetal fashion. Thus prepared, the flaking surface then served for the production of elongated or short, broad-based Levallois points and sub-triangular blanks, using either the recurrent or the lineal method (Fig.147, Nr.2-4, 6-8). As has already been shown for assemblage 5AII, both Levallois methods were intrinsically related in the course of Levallois point production. Sporadically, the quadrangular flakes were produced with the lineal method (Fig.147, Nr.10). The cores are non-diagnostic in terms of principal flaking technology because of their intensive reduction. The five identified nodule cores suggest an anterior point production before they were finally exploited in a rather opportunistic way (Fig.147, Nr.12).

The dominant tool category is composed of naturally backed knives, which are actually by-products of Levallois point production in the earlier stage of core reduction.

Retouched tools are rare in level 5AIV and account for not more than 5.2% of the total assemblage, excluding small chips. The sample is composed of side scrapers and partially retouched Levallois blanks on which retouch is sometimes found on the ventral face (Fig.147, Nr.9, 11). The noticeably high number of broken implements (29 out of 50 retouched tools) could reflect an intensive use of retouched tools. As soon as they lost their functional value, they seem to have been systematically recycled as cores on flakes.

A.2.5 Assemblage 5AV

Assemblage 5AV reflects the importation of Levallois cores which were already reduced to a considerable extent. They were further exploited in Hummal, where they delivered a few Levallois blanks with a length between 7cm and 5cm. The low productivity of imported cores is mirrored by a very low debitage-to-nodule core ratio (Tab.47). The cores are represented by three opportunistically exploited flake cores and one Levallois core which shows a final point; the nodule cores are accompanied by two cores on flakes. The brevity of blank production is also reflected by the low number of core trimming elements. Yet the high amount of small debris stands in contrast to the small number of on-site produced blanks. Although the debris is not analyzed in detail, it is possible that a considerable amount stems from the manufacturing of tools that were subsequently taken to other localities.

The predominance of the unidirectional convergent scar pattern and the technological features of Levallois points warrant an attribution of assemblage 5AV to the HM-A1 industry.

A.2.6 Assemblage 5AVI

(Fig.148)

Due to the disturbance of the archaeological situation which was recorded for level 5AVI, the lithic sample can only be considered as an incomplete and probably unreliable picture of Mousterian lithic organization. Nevertheless, the palimpsest contains some interesting techno-typological elements. To be mentioned are broad-based Levallois points, which belong to two types. The first type comprises preferential points which exhibit three dorsal negatives, a *chapeau de gendarme*, a Concorde-type of lateral profile and perfect symmetry in their longitudinal axis (Fig.148, Nr.1). The second type includes points, the production of which involved more than three anterior removals on the flaking surface and an extension of the faceted striking platform (Fig.148, Nr.2). These points were obtained with the special Levallois point technique, which characterizes the HM-A1 industry. The majority of Levallois flakes and blades, which predominate in assemblage 5AVI, can be related to one of the two Levallois point production strategies; these blanks exhibit a sub-triangular morphology and unidirectional convergent scar patterns (Fig.148, Nr.3). The one-axis core reduction concept also involved the unidirectional parallel flaking method to obtain elongated flakes and blades. Unfortunately, no Levallois cores have been found yet, and the core group is composed of three extremely reduced flake cores and three cores on flakes (Fig.148, Nr.6). Given the small sample size, level 5AVI revealed a surprisingly high number (n=8) of side scrapers and a partially retouched blank (Fig.148, Nr.4, 5, 7).

A.2.7 Assemblage 5BII

The analyzed lithic sample of level 5BII reflects a site provisioning strategy that centered on imported Levallois blanks. In Hummal, the imported tool kit was enlarged with a few on-site produced blanks for which flint pebbles in secondary outcrops were collected. Assemblage 5BII was allocated to the HM-A2 industry of Hummal because of the following techno-typological aspects: the morphology of Levallois points and the significance of Levallois flake and blade production with the unidirectional parallel method. Although the majority of Levallois points exhibit a broad base, their technological features do not resemble those of the HM-A1 industry found in the overlying complex 5A. To be mentioned is the lesser convergence of dorsal negatives and lower frequency of the *chapeau de gendarme*; the same holds true for point-related Levallois blades and flakes. The points in level 5BII are rather reminiscent of the short specimens found in the 5b levels of the western section and thus corroborate a tentative correlation of the V2 complexes in both areas of Hummal. Many flakes and blades with unidirectional scar patterns show that Levallois point production was accompanied by the application of the recurrent unidirectional parallel method. Flakes with centripetal scar patterns are absent. On-site core reduction followed two principal strategies, which are the recurrent and preferential production of Levallois points and the recurrent production of Levallois flakes and blades. The two Levallois cores evidence traces of both strategies, as do the cores on flakes (Fig.149, Nr.1). The cores on flakes and four double patinated flakes reflect the economizing of raw material use, which probably gained importance as soon as the imported blanks lost their functional value. The need for retouched tools seems to have been low, as they account for only 7.1% of the total assemblage, excluding small debris.

A.2.8 Assemblages 5DII to 5DV

(Fig.149)

Only a small sample of 8 lithic artifacts was found in levels 5DII, 5DIII and 5DIV. The 5DII sample comprises a Levallois point (Fig.149, Nr.2) and one core trimming flake; the 5DIII sample contains one core trimming flake, two non-diagnostic fragments and one core; the 5DIV sample comprises a non-diagnostic fragment and one core fragment. While this sample is definitely too small to draw any conclusions as regards techno-typology and lithic organization, the quantity of material recovered in level 5DV is sufficient for a more detailed study (Tab.9). The technological composition of assemblage 5DV reflects an on-site production of elongated Levallois points and triangular blades which are by-products of point core reduction (Fig.149, Nr.3, 4). Some blanks were presumably imported, as their size clearly exceeds the size of core trimming products. A nice example is a double convex side scraper which was manufactured on a Levallois blade (Fig.149, Nr.5). Core reduction waste is represented by cortical pieces and flakes which stem from the maintenance of the flaking surface and striking platform. Broken pieces are relatively frequent (35%) and most of them are proximal fragments of Levallois blanks. Although we are not sure whether they belonged to Levallois points, it is possible that these fragments represent broken extractive tools, such as hunting weapons or blades which were used as cutting knives. Hence, assemblage 5DV may reflect a visit to the site to perform a certain task (butchery?) and for the purpose of retooling. These activities also required small non-Levallois flakes, which were struck from the ventral or dorsal face of large fragments. Four cores on flakes and one Kombewa flake are remains of this secondary flaking technique. The aim of retooling was to obtain fresh and sharp edges, whereas retouched tools were presumably of low significance as only two modified blanks are found in the sample.

A.2.9 Assemblage 5E

(Fig.150)

Due to the high proportion of Levallois blanks compared to core trimming elements and cores as well as its import value, assemblage 5E is seen as the waste of site frequentations during which the majority of blanks and tools was imported. Some cortical flakes and core trimming elements, as well as 11 cores – of which 9 are made on flakes – show that at least some blanks were produced in Hummal. A remarkable feature of level 5E is the high number of elongated Levallois points and blades (Fig.150, Nr.1, 2, 3); the point sample has a mean length-width ratio of 2.6, which is the highest value recorded across the Mousterian sequence. The Levallois blanks were all produced from a single striking platform; perpendicular scar patterns are scarce (Fig.150, Nr.3), and bidirectional or centripetal patterns are lacking. Many points are of the “leaf shaped” type and were produced in a recurrent unidirectional fashion on the same core with Levallois blades and flake, for which parallel running scars were used. Some points with relatively broad base and three dorsal negatives evidence the use of the lineal method. The high number of distal and proximal Levallois blank fragments is presumably the result of an intensive use of these tools. As retouched tools account for only 6% of the total assemblage, the elongated blanks were used in an expedient way. The aim of core reduction was probably to obtain long, regular cutting edges, and their high degree of craftsmanship in knapping enabled the Mousterian inhabitants to meet this requirement without an elaborate tool manufacturing process. Broken flakes and blades were frequently recycled into dorsal cores from which two or three bladelets or small, triangular flakes were removed (Fig.150, Nr. 4, 5). An alternative secondary blank production was based on the ventral surface of large flakes. Although the corresponding end-products are lacking, it is possible that the technique is similar to the Levallois point production on flakes, which was identified, for example, in level 5AII. If this is the case, the Kombewa and Janus flakes can be seen as related by-products (Fig.150, Nr. 5). Noticeable among the retouched tool group are two perfectly designed, elongated Mousterian points, of which one is illustrated in Figure 150, Nr. 7. Viewed against the archaeological background, assemblage 5E constitutes a suitable sample for microwear analysis, for which we will hopefully get permission.

B Catalogue: Upper Pleistocene and Holocene deposits

The depositional sequence is described from top to bottom. Corresponding information can be found in tables 3 and 4; the stratigraphy is depicted in figures 13, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27. The Holocene deposits found in the western and southern part of Hummal are described together because of unequivocal correlations. The catalogue of Pleistocene deposits is separately presented for each section.

B.1 Holocene deposits

B.1.1 Complex I

Section: West, South

Archaeological level: none

Profiles: P42, P43, P48, P49, P59, P71

Complex I comprises the modern-day surface and recent backdirt that originated either from archaeological excavation or well constructions carried out by the present owners of the well during the last century. Whenever possible the remains of these two different activities were separately recorded (layer I1 = backdirt from excavation; layer I2 = backdirt from well-construction and maintenance). These unconsolidated deposits contain of a wide variety of constituents ranging from coarse gravel to silt and often present an inverse stratigraphy. Many lithic artifacts and few ceramics from different periods can be found in layer I2 and their presence on deflation surfaces enabled the discovery of the site in 1966. The sediment stems from the digging of the well in the spring's center and from channels departing from there in different directions. Depending on the position of excavation areas and former well constructions the backdirt attains variable thicknesses with huge piles in the northwestern, southern and eastern part (Fig.3).

B.1.2 Complex II

Section: West, South

Archaeological level: none

Profiles: P42, P43, P44, P45, P48, P49, P59, P69, P71

Sediment complex II represents the major part of the modern well's infill and comprises several layers with a different composition and depositional context. A common characteristic is the presence of unconsolidated sediment with a high density of gypsum and a bioturbationally reworked texture. It is generally identified as gypsitic sand or as a gypsitic carbonate sand-silt mixture. In the excavated sections, sediment complex II either directly overlies *in situ* Pleistocene deposits or it appears above layer III.

In the southern part of Hummal it is represented by a homogenous sand-silt facies consisting of carbonates and gypsum. A calcic horizon, which represents the formation of an aridisol, is located on top of it. On the basis of a sample taken from profile P71 it was shown that the sediment mainly consists of altered, well-rounded carbonatic clastics of different type with a size below 1mm; evidence for a secondary carbonate precipitation was also found. Traces of bioturbation due to rodent or insect activity and present-day vegetation are omnipresent.

In the western section of the well, complex II can be subdivided into at least six layers which were sampled for micromorphological analysis (Meyer 2007; Fig. 20, Fig.21). Directly below recent backdirt deposits a bioturbated gypsitic sand layer (II1) was identified showing a diffuse upper and a distinct lower limit. Depending on the depth of modern-day intrusion during field work, its thickness is varying with a maximum of 60cm. The sediment is unconsolidated with a high porosity (25-30%) and chaotic alignment of constituents, such as littoral carbonate clastics, gypsum crystals and quartz sand. It is assumed that the gypsum and quartz sand fraction was transported into Hummal by wind energy, whereas the carbonates have a local origin. Layer II1 probably represents a short and high-energetic rearrangement process in the course of well constructions during which different elements were mixed together. At the transition of layer II1 and layer II2 a thin concentration of micrit was identified which was transported from above by infiltrating water and accumulated on top of layer II2. This layer which is clearly recognizable due to its dark brown color comprises the same constituents as layer II1 but shows a sorting of these elements and lower porosity. Intensive bioturbation is indicated by worm-holes and termite excrements. At the base of layer

II2 a thin, 10cm thick concentration of gypsum crystals with a low amount of carbonate clastics was identified in profile P42. It probably represents a short-term accumulation of aeolian sediment. Despite its light-brown color which distinguishes it clearly from the over- and underlying gypsitic sands, the composition of layer II3 is roughly comparable to them. However, the proportion of littoral carbonate is higher (50-60%) and the clastics are larger and exhibit an angular morphology. The presence of pure carbonate concentrations indicates that layer II4 was originally accumulated during a period when the spring was still active. Subsequent desiccation saw a weathering of littoral carbonates and an introduction of allochthonous constituents such as wind-blown gypsum and quartz particles. Bioturbation provoked an alignment of gypsum crystals along root cracks and worm-holes. This freshwater carbonate is underlain by dark-brown gypsitic sand layer (II4) whose composition is identical to layer II2. A second carbonate deposit appears again in layer II6. The lower limit and the transition to layer III is irregular and lenses consisting of both sediment types appear intermingled in the contact zone. The cause of this mixture is unclear but it can be assumed that bioturbation caused the reworking vertical displacement of fine-grained constituents. In the north-south running profile P43 a light-brown colored silt deposit (layer II5) appears before this transitional zone. As this deposit was not sampled for sedimentological analysis it is unclear whether it represents a distinct gypsitic carbonate facies or just a sub-layer in layer II6 with a higher amount of carbonate clastics.

B.1.3 Complex III

Section: West, South

Archaeological level: 3

Profiles: P42, P43, P48, P49, P58, P59, P63, P64, P65, P69, P71

Layer III is a grey colored, unconsolidated carbonate silt deposit which was identified in the southern, western and northern section of Hummal. It is always situated in disconformity on top of the *in situ* Pleistocene sequence and exhibits a varying thickness of 30 to 40cm; in the northern section, the layer attains a thickness of over 1m. The deposit lacks any structure and is principally composed of well-rounded, travertinized carbonate clastics stemming from the littoral zone together with quartzitic sand and a high frequency of gypsum crystals. Iron oxide precipitations indicate fluctuations in humidity, and the presence of quartzitic sand can tentatively be related to dry periods during which aeolian sedimentation prevailed. In the western section, an enormous quantity of gastropods were found in the vicinity of a channel-like structure which is visible in profiles P49 and P51 (Fig.20). The sediment’s texture was post-depositionally destroyed by several factors: borrowing rodents, vegetation, and the construction of the well in historic and modern times.

Interpretation of the depositional context of layer III is not clear yet. In the western section many lithic artifacts were found, whereas in the southern section it seems to be sterile. The lithic assemblage shows a mixture of Neolithic, Upper Paleolithic, and Mousterian artifacts together with ceramic sherds of unknown age. On the basis of this observation, layer III was interpreted as a Holocene colluviation. In addition, the channel-like structure visible in the western section could represent a gully running north-south and filled up with weathered littoral carbonates. In the present state of analysis, only a working hypothesis can be formulated concerning the depositional context. Layer III represents an intensive alteration, erosion and re-deposition of originally *in situ* littoral carbonates during a period of increased rainfall and/or human activity in the context of a well construction. A major stratigraphic hiatus is recorded between the uppermost Pleistocene deposits and layer III. Therefore, it is assumed that a significant part of the upper Pleistocene sequence was eroded and partially re-deposited together with more recent material. The deposit underwent several alterations and disturbances, and it is possible that colluvation processes played a significant role leading to repetitive accumulations at the base of the spring funnel (chapter 4.3). The sediment was exposed to weathering for an extended period and the erection of working surfaces in the course of historic and modern well constructions could have had a significant influence in this respect.

B.2 The Pleistocene deposits in the western part of Hummal

B.2.1 Layer V1-1

Section: West

Archaeological level: 5a1

Profiles: P48, P49, P64(?), P65(?)

Layer V1-1 is a loosely sorted and porous sediment which contains a mixture of weathered littoral carbonates and infiltrated gypsitic sand. As its composition appears similar to that of layer III it is yet unclear whether it truly represents the uppermost Pleistocene deposit in the western section. The fact that the sediment consists to a large extent of littoral carbonates, however weathered and disturbed in its upper part, a tentative attribution of layer V1-1 to the Pleistocene sequence seems warranted. Truncated by layer III at its southern extension, it is only visible in the eastern half of profile P49 and the northern part of profile P48 (Fig.20).

Layer V1.1 is not found *in situ*, and it is yet unclear if a major dislocation and subsequent re-deposition of the sediment caused the mixing of several archaeological levels as lithic artifacts were found in an irregular position. A second erosion process probably occurred before or during the deposition of overlying layer III which coincides with the channel-like disturbance running north-south. Post-depositional alteration of the sediment was intense due to bioturbation and chemical weathering which is especially pronounced in the vicinity of the erosion channel. In this area, secondary carbonate precipitation in the context of increased humidity provoked the formation of a soft, white-colored deposit which resembles lake marl.

B.2.2 Layer V1-2

Section: West

Archaeological level: 5a1

Profiles: P42, P49, P64(?), P65(?)

This 20cm thick silt deposit was identified only in the eastern part of the western section, and is thus only documented in profiles P42 and P49. The cemented carbonate shows a platy texture interspersed with tabular limestone pebbles; it is therefore possible that a cryoturbation processes affected layer V1-2. However, micromorphological analysis has not revealed respective features, and this question has to remain open. Micromorphologically, the sediment shows a crackly texture and an infiltration of fine-grained material such as carbonate clastics, gypsum and termite excrements along fissures (Meyer 2007). Major constituents are carbonate mud (40%), quartzitic sand (10%) and well-rounded littoral carbonate clastics (25%). This type of detrital silt represents the remains of weathered littoral carbonates which eroded into the lake and were then rolled and embedded within a micritic substrate. Subsequent desiccation caused the opening of cracks which became filled with carbonate clastics and biogenic elements. In addition, increased evaporation triggered the precipitation of gypsum crystals. A part of the lithic palimpsest 5a1 was found in layer V1-2 and the intensity of diagenetic processes with which this deposit was affected explains the lack of *in situ* archaeological levels in the uppermost part of western Mousterian sequence.

B.2.3 Layer V1-3

Section: West

Archaeological level: 5a1

Profiles: P42, P43, P48, P49, P64(?), P65(?)

The transition between layer V1-2 and this carbonate silt deposit is very diffuse and macroscopically only discernable by a change in color from a brownish grey to grey and increasing consolidation of the freshwater carbonate. Layer V1-3 is a massive deposit with a maximum thickness of 60cm and is found all over the excavated sequence. In the northern part from Y=37 onwards it is followed by travertine gravel (layer V1-4), whereas in the adjacent southern part, it eroded a soil formation (layer V1-5).

Micromorphological analysis shows that compared to overlying layer V1-2, the amount of detritus is low and the sediment mainly consists of *in situ* littoral carbonate (Meyer 2007). The proportion of quartz sand and carbonate clastics is low with 5% each. Likely, organic constituents, such as termite excrements found in fissures are sparse. Formation of gypsum crystals in pores and fissures was probably triggered by infiltration water. A loose concentration of heavily patinated artifacts was found in the upper part of layer V1-3, belonging to the palimpsest assemblage 5a1.

The thick littoral carbonate deposit can be correlated with a water transgression. Although layer V1-3 was defined and analyzed only in the western section of Hummal, this deposit probably has a wide extension and should therefore equally be found in other parts of the well; it is possible that it correlates with layer S-V1-1 in the southern part of the well.

B.2.4 Layer V1-4

Section: West

Archaeological level: none

Profiles: P48, P49, P54, P65, P66

A deposit consisting of coarse travertine gravel appeared in the excavated area from Y=36 onwards in northern direction. Its base has not been identified yet, and hence the layer's extension is unknown. Its exact stratigraphical position equally remains to be clarified. An important question that has to be solved is the sequential correlation between the travertine formations and adjacent limnic deposits containing archaeological remains. In the present state of analysis, the massive littoral travertine found in trench W2 can be seen as a consolidated lake margin which successively precipitated during the deposition of complex V1. Layer V1-4 could stem from the weathered top of this travertine complex with large angular clastics of several centimeters forming a scree deposit. In profiles P54 and P66, the cree’s steep gradient is visible and this conical structure lacking any sorting suggests that a debris fan rapidly accumulated during a period in which the spring was deep funnel-like depression. If this is the case and layer V1-4 in fact corresponds to the travertine complex identified in adjacent areas, it is presumably older than layers V1-5 to V1-8, and has consequently to be placed further down in the stratigraphical sequence. If however a correlation of layer V1-4 with the underlying travertinized detritic carbonate deposit whose sedimentology and stratigraphical position remains unclear as yet (see below) is proven, its accumulation occurred at least after the deposition of layer V2-4. Complicating this question is the fact that that in profile P60 layers V1-3 to V1-8 lack any horizontal connection with the scree. However, the horizontal alignment of the tabular travertine clastics seems to contradict a high energy colluvation, and thus, layer V1-4 can alternatively be interpreted as an intensively weathered *in situ* travertine.

B.2.5 Layers V1-5, V1-6, V1-7 and V1-8

Section: West

Archaeological levels: 5a2 in layer V1-5, 5a3 in layer V1-8

Profiles: P28, P29, P42, P50, P53

Layers V1-5 to V1-7 are described together as they belong to a single depositional context which can be characterized by alternations between a carbonate precipitation in oxygen-rich freshwater and the accumulation of detrital facies in an oxygen-depleted, marshy environment. These alternations occurred very rapidly leading to a laminated deposit in which not all detrital depositions are visible to the naked eye. Altogether, this part of the upper Pleistocene sequence attains 70cm and comprises at least two major phases of detritus accumulation coupled with a precipitation of iron-oxides and gypsum crystals during water regressions. Intercalating with these detritic carbonatic silts are littoral carbonates (layer V1-6) or sublittoral carbonates (layer V1-8) rich in limnic elements, such as ostracods, oogones and algae. Ongoing desiccation and intensive weathering in the proximity of the well funnel caused a strong alteration of the sediment, in the form of gypsitic accretions and concretions of iron oxides in fissures and pores. Moreover, open cracks in the sediment were filled by younger carbonate clastics and termite excrements. Therefore, a differentiation of minute changes in texture or composition is impossible, and it has to be considered that probably more than two detritic phases have left their mark without being recognizable anymore. Layers V1-6, V1-7 and V1-8 were sampled for micromorphological analysis (Meyer 2006), and as layers V1-5 and V1-7 show similar features, results for the latter can roughly be applied to the former. It is possible that this sequence correlates with layers S-V1-1 to S-V1-6 in the southern part of Hummal. The identified layers V1-5, V1-6, V1-7 and V1-8 exhibit a slight inclination of about 15° to the east and south. Their lateral extension is difficult to determine; the detrital facies are no longer identifiable from X=99 westwards, and to the east both layers are cut by an erosional channel. This observation coincides well with the horizontal distribution of archaeological remains and it is possible that from X=99 to the west different depositional contexts existed (Fig.37). In area Y=33-36 / X=99-105, which covers about 18m^2, two archaeological levels (5a2, 5a3), which correlate with the detrital carbonatic silts, were identified.

Intensive iron-oxide and manganese precipitations as well as root traces are the only remnants of a pedogenic process in layer V1-5. As it was not sampled for sedimentological analysis, no information can be provided regarding composition and texture. Its thickness does not attain more than a few centimeters and it can be assumed that the interval of pedogenesis was relatively short. Yet an indication that the surface laid open for a while is the lack of faunal remains in the archaeological assemblage. This distinguishes layer V1-5 from the lower detrital facies in layer V1-7 in which bone conservation is better and many specimens are covered by a calcitic encrustation. Layer V1-5 is followed by an *in situ* littoral carbonate deposit with only few liminic elements and intensive iron-oxide precipitation which adds it an orange color. The sediment is consolidated and exhibits polygonal fissures which probably resulted from ongoing desiccation and weathering. Bioturbation is found in the contact zone between the deposit and the modern well infill. The following lower detritic carbonate mud in layer V1-7 is more distinct than the upper one and micromorphological analysis shows that it consists of fine and medium grained micrite which is interspersed with well-rounded carbonate clastics. The clastics' significant rounding indicates that initially weathered littoral carbonates eroded into the spring pond where they faced an alteration under a more or less constant water cover. A collapse of the lake system is evidenced by the presence of clay minerals, root traces and an incomplete redox reaction of iron, all of which indicate a pedogenic facies in the context of an oxygen-depleted, marshy environment. It is possible that excessive growth of algae in a closed lake lead to anaerobic conditions in which iron ceased to oxidize and caused the sediment's greenish color. Post-depositional desiccation provoked the accretion of gypsum crystals in pores and the opening of fissures in which carbonate clastics and organic material infiltrated. The detritic carbonate mud overlies an in situ freshwater carbonate (layer V1-8) which precipitated during a transgression phase as is evidenced by the high density of limnic elements.

B.2.6 Layer V1-9

Section: West

Archaeological level: 5a4

Profiles: P44, P45, P50, P53

Layer V1-9 represents the lowest facies of the uppermost Pleistocene sediment complex. Its appearance is very similar to the detrital carbonate mud found in underlying layer V2-2. For this reason, layer V1-9 could equally be attributed to sediment complex V2. The olive green color suggests that deposition occurred in reducing conditions during a period of decreased spring activity. The deposit's spatial distribution is irregular with lenses being several centimeters thick next to areas where layer V1-9 is no longer present. It is possible that several diagenetic processes were responsible for this pattern. Parts of layer V1-9 were probably eroded during the following water transgression as can be seen by the unconformity between layer V1-8 and V1-9 from Y=35 onwards (Fig.21). In addition, the deposit's constant aeration and drainage and the formation of cracks caused a vertical displacement of fine grained sediment particles. The post-depositional processes had a rather low energy. This assumption is based on the fact that the archaeological remains are well preserved with no edge abrasion visible on lithic artifacts and a high density of small lithic debris.

Layer V1-9 was not sampled for micromorphological analysis yet, but it can be assumed that its composition and texture is roughly similar to that of other detrital carbonate muds found in sediment complexes V1 and V2. Like in layers V1-5 and V1-7, the combination of a pedogenic facies with archaeological remains in layer V1-9 once again shows that Hummal was a preferred settlement site during moments when the spring had a low water table and vegetation developed inside the mound.

B.2.7 Layer V2-1

Section: West

Archaeological level: 5b1

Profiles: P44, P45, P50, P53

Layer V2-1 accumulated during a period of increased spring activity favoring carbonate precipitation and growth of aquatic plants. However, the milieu was not constantly an open, oxygen-rich lake system but alternated with several short-term phases during which no fresh water input was given. The result is a 20 to 30cm thick deposit consisting primarily of chalky freshwater carbonates enclosing several thin, olive green colored clay beds. This type of sediment is called a laminated carbonate mud and appears in several sections of the Mousterian sequence such as in layers V3-4, V3-5 and S-V4-1-2 in the southern part of the well. Layer V2-1 was sampled for micromorphological and sedimentological analysis (Meyer 2006). Its composition shows a predominance of slightly rounded freshwater carbonate clastics with a size between 1 and 10mm. Very frequent are limnic elements such as calcified stems of *Characea*, oogones, octracods and algae. The proportion of quartzitic sand is low with only 5%. Micrit consisting of fine sand forms the matrix which shows a low porosity and cracky structure. A significant part of layer V2-1 was eroded during the deposition of layer V1-8 and therefore the deposit was not found in the northern part of the western section. In the southern part, layer V2-1 appears as a cemented silt deposit which was altered by intensive weathering, especially in the vicinity of the well funnel. Microscopic analysis shows that ongoing desiccation lead to the formation of cracks which became filled with brown colored carbonate debris stemming from overlying deposits. The thin clay levels are only hardly visible with the naked eye and it is therefore impossible to sample them separately. Furthermore, any definite attribution of archaeological remains to any of these sub-layers is not warranted. Nevertheless, current hypothesis states that Mousterian hominids generally occupied the spring during moments of decreased spring activity, and hence, the corresponding remains are more likely to be correlated with the thin clay deposits. Lithic artifacts and faunal remains were rapidly embedded by freshwater carbonates, and consequently, preservation of archaeological remains is excellent in layer V2-1.

B.2.8 Layer V2-2

Section: West

Archaeological level: 5b2

Profiles: P44, P45, P50, P53

Layer V2-2 is a thin olive green clay accumulation which was found as remnants in shallow depressions where they attain a maximum thickness of around 6cm. A significant part of layer V2-2 was either eroded during a rapid water transgression or post-depositional diagenesis caused a vertical dislocation of fine grained material along fissures. As a result, the deposit was only identifiable in the southern and northernmost part of the excavation surface. In the latter area, the clay accumulation is found as several millimeter thin beds with cemented freshwater carbonates in between them. Well preserved artifacts and animal bones were found as a thin concentration within the lens-like clay accumulations.

Micromorphological analysis (Meyer 1006) corroborated these observations made in the field and identified layer V2-2 as a detrital carbonate mud which has a lamellar structure. Its composition is dominated by inorganic materials such as carbonates (40%), gypsum (10-15%) and quartz sand (2%). Ostracods are present and point at a limnic context of deposition. The clay accumulated in an oxygen-depleted milieu and became subsequently enriched with carbonate clastics. These particles were probably transported by water flows as they exhibit a well rounded surface. The same holds true for the archaeological remains which were embedded in the fine grained sediment after a minor displacement over short distances.

B.2.9 Layer V2-3

Section: West

Archaeological level: none

Profiles: P44, P45, P50, P53

Layer V2-2 appeared as a white colored, chalky sediment which became cemented due to ongoing desiccation. Its thickness varies between 2 and 10cm. The carbonatic silt accumulated during a period of increased spring activity within the context of an open lake system. The input of oxygen-rich freshwater triggered carbonate precipitation and the emergence of mollusks and algae. Although not being visible in the thin section, we observed fine-leveled clay beds in layer V2-2 during excavation. Therefore, the deposit is referred to as a laminated carbonate mud comparable to the sediment type found in overlying layer V2-1. Typical components are limnic elements such as oogones, ostracods and algae.

B.2.10 Layer V2-4 to V2-12

Section: West

Archaeological levels: 5b3, 5b4, 5b5, 5b6, 5b7

Profiles: P4, P6, P44, P45, P50, P51, P52, P53

The lower part of sediment complex V2 shows a regular alternation of detrital carbonate mud (layers V2-4, V2-6, V2-10, and V2-12) and freshwater carbonates (layers V2-5, V2-7, V2-9, and V2-11) (Fig.23). The depositional sequence probably represents a fluctuating water table during a period of increased spring activity. The detrital muds contain a high density of well preserved archaeological remains whereas the freshwater carbonates revealed only a few artifacts or were completely sterile. Layers V2-4 to V2-12 are described together because it is assumed that they belong to a specific moment in the site formation process which is characterized by successive colluvations of travertine clastics interrupted by *in situ* carbone precipitations. The detrital facies are easily identifiable due to their high amount of travertine debris and pebbly texture. In their southern extension, the two uppermost detrital layers V2-4 and V2-6 appeared as one single grey-beige colored deposit becoming increasingly thinner towards the opening of the spring mound (Fig.21). Therefore, they were identified and described as one archaeological level (5b3) in 2004. With the ongoing surface excavation in the adjacent northern part in 2005, we observed a splitting of level 5b3 into two facies from axis Y=34 onwards. Between them, a travertinized, sterile carbonatic silt (layer V2-5) appeared. This observation prompted us to divide archaeological level 5b3 into two sub-levels, namely 5b3-1 and 5b3-2. The upper detrital layer V2-4 Layer V2-4 shows a slight bedding of sand lenses and fine-grained carbonatic gravel and was sampled for micromorphological (Meyer 2006) and sedimentological analysis (Martineau 2009). The sediment consists primarily of micrite and carbonate clastics such as travertine and littoral carbonate fragments with a maximum size of 1cm. In the thin section these particles showed a low sphericity whereas in the sedimentological analysis they were identified as well rounded clastics. This disparity of results can probably be explained by the different sampling loci; the sediment sample was taken in the southern (profile 44) and the micormorphological sample in the northern part (profile 50). The texture is characterized by a high porosity and many microfissures in which iron oxides and gypsum precipitated. Organic components are small rounded bone fragments and charcoal flitters. The carbonatic silt which was found below layer V2-4 is a typical *in situ* freshwater carbonate with many limnic elements (ostracods, oogones, and algae). A significant part of layer V2-5 was eroded before or during the deposition of layer V2-4. Constant aeration and drainage of the sediment provoked a secondary travertinization, and thus, heavy tools were needed to remove this layer. The following detrital mud in layer V2-6 shows exactly the same characteristics which were identified for layer V2-4. Layers V2-7 and V2-9 are again freshwater carbonates in which no archaeological finds appeared. Located between them, a thin green to brown colored clay deposit was truncated by the overlaying silt layer in its southernmost part. Macroscopically, layer V2-8 reveals the same composition and texture as layer V2-2 and was equally deposited during a regression of the water table. A small number of lithic artifacts, faunal remains and charcoals were discovered within the clayey matrix. Following layer V2-10 is the third detrital mud accumulation which is roughly comparable to layers V2-4 and V2-6. However, with an average thickness of 15cm it has a greater volume than the upper detrital layers. Another difference is the clearly visible sorting of clastics according to their size resulting in thin silt beds alternating with concentrations of coarser travertine gravel. Bioturbation was more intense than in other layers and many root traces coated with iron oxide precipitations were found. As in layers V2-4 and V2-6, a high density of well preserved archaeological remains was discovered in test pit W1. A preliminary sedimentological analysis of layer V2-10 revealed the presence of quartz sand (minimum 10%) and about 50% of the grains exhibit a rounded matt surface. This indicates an accumulation of wind-blown material during a period of increased aridity. Following a sterile carbonatic silt (layer V2-11), which is the lowermost *in situ* fresh water carbonate found in the western section so far, is the fourth detrital facies, layer V2-12. Having a mean thickness of 20cm it is the thickest of the four detrital carbonate muds. As in layer V2-10 coarse carbonate gravel alternates with fine-grained material which is found as lenses especially at the base. Another point in common is the presence of aeolian quartz sand in the sieving residues. Although we excavated only a small part of this layer, it seems that the density of finds in layer V2-10 is lower compared to overlying levels 5b5 and 5b3.

B.2.11 The detrital carbonate mud: a model of deposition

An important question regarding the depositional context of the detrital carbonate mud concerns the origin of the travertine clastics found in them. As they cannot be derived from the over- and underlying freshwater carbonates the parent material must be located somewhere else. It is highly likely that the travertine gravel is the product of an intensively weathered travertine formation which developed at the rim of the spring mound (chapter 4.4). If this correlation proves to be correct, what does this mean for the interpretation of archaeological levels 5b3, 5b5, and 5b5? In the current hypothetical model, we assume a successive weathering of a massive travertine during times of decreased spring activity. According to micromorphological interpretation the milieu of deposition was a closed, oxygen-depleted lake system (Meyer 2006). The mud accumulated at the base of the persisting pond and became enriched with the allochthonous clastics. A following transgression of the water table and subsequent precipitation of freshwater carbonates covers the detrital mud. This process which is related to a constantly changing environment occurred at least four times (Fig.31 and Fig.151). From an archaeological point of view, the question is now whether the Mousterian settlements were located on top of the weathering travertine or on the already accumulated travertine debris in the spring mound. In the latter case, archaeological levels 5b3, 5b5 and 5b5 can be regarded *in situ*. In the former case, the archaeological remains would have been displaced together with the weathered carbonates. As has been shown in chapters 5.1.6, chapter 5.1.8 and chapter 5.1.10, the lithic artifacts lack any traces of transport. However, a sudden run-off of fine-grained sediments does not necessarily be identifiable by the preservation of lithic artifacts.

B.2.12 Layer V3

Section: West

Archaeological level: none

Profiles: P4, P6, P44, P45, P51, P52

Layer V3 is the upper one of two massive colluvial deposits which are located at the base of the western stratigraphy. It appears as compacted, unstructured carbonatic silt with a light grey-brown color. The sharp boundary between layer V3 and the overlaying detrital mud of layer V2-12 indicates a gap in the depositional sequence. Many root traces as well as precipitations of iron oxide and manganese can be seen as remnants of a former pedogenesis on top of layer V3. It is possible that a cavity developed in the depositional sequence due to a collapse of unstable sediments. This cavity was later filled with more recent material eroding from the upper part of the sequence. Whether this depositional model is plausible or not cannot be answered with certainty as the colluvium's extension has not been reached yet. To the south it is truncated by the modern well funnel and to the north it seems to become increasingly thicker. A few artifacts were found in irregular position which is a typical phenomenon of colluviated deposits.

B.2.13 Layers V4-1, V4-2, and V4-3

Section: West

Archaeological level: 5e

Profiles: P4, P6, P46a, P51, P52

In 1999, level 5e was described in profiles P4 and P6 as a deposit with alternating accumulations of clay and silt in which numerous artifacts appeared. In 2006 we opened test pit W3 to reinvestigate this sediment complex among other things because profiles P4 and P6 were too strongly weathered and sampling was therefore no longer possible. Although, archaeological level 5e was identified in trench W3, the exact correlation of this level, now termed complex V4 and subdivided into three layers, with the one defined in 1999 went not without problems. Furthermore, a marked upward gradient and gradual disappearance of complex V4 after two meters to the west hampered a detailed differentiation and investigation of layers V4-1 to V4-3. The distinct inclination and increasing thickness of complex V4 towards the center of the spring mound could be the result of a gradual collapse of deposits due to instabilities underground (chapter 4.5.4). This assumption is however to be seen as arbitrary as geomorphological, sedimentological and micromorphological investigations are still lacking. The differentiation of three layers is based on quantitative differences in fine-grained material, gypsum, and quartz sand as well as color. Layer V4-1 presumably represents a pedogenic process because of a high density of clay minerals, gypsum and calcified plant remains. In layers V4-2 and V4-3, a decreasing clay proportion and increasing density of carbonate clastics and detritus seem to evidence the deposition of detrital carbonate mud which involved the accumulation and subsequent rounding of weathered littoral carbonates in shallow water.

The gray-light green color of sediment complex V4 is an indication for a reduced redox-potential in an oxygen-depleted environment. Within this closed system, vegetation developed and lead to the formation of a soil. Bone material was not preserved except for some robust teeth fragments, and the lithic artifacts exhibit a light-brown to white colored patination which is different to the patina found on artifacts in overlying deposits. It is possible that both chemical diagenesis as well as slow rates of deposition were responsible for the emergence of these features.

B.2.14 Layers V5-1, V5-2, V5-3, and V5-4

Section: West

Archaeological level: 5f1, 5f2

Profiles: P4, P6, P51, P52

The upper part of complex V5 shows a strong pedogenic modification of a gypsitic carbonate substrate. Layer V5-1 is easily identified by its dark green-brown color and highly porous texture. Embedded within this type of evaporitic sediment were lithic artifacts and a few poorly preserved faunal remains. Noteworthy is the absence of a quartz sand fraction which in other cases is a regular component of this clay-rich, palustrine carbonate. Underlying layer V5-3 can be differentiated by a higher proportion of carbonate clastics which exhibit well-rounded surfaces. This is an indication of at least one interval of reworking through wave attack during a period of water transgression. Moreover, the sediment was significantly bioturbated by the soil formation in layer V5-1. The high density of vertical root traces in which iron oxides and gypsum precipitated as well as infiltrated clay minerals are typical features thereof. The onset of the reducing conditions which are evidenced by the palustrine carbonates of complex V5 is found in layer V5-4. Microscopic analysis (Meyer 2001) identified an accumulation of fine-grained micrite which was intermingled with carbonate clastics from underlying layer V6-1. Deposition probably occurred during a dry period with a persisting ephemeral or perennial lake surrounded by a swampy environment. Aeolian input from adjacent *sabkha*-formations was significant. A dense vegetation cover is evidenced by a high density of calcified roots and stem fragments.

The status of layer V5-2 is insecure. It was retrospectively defined in profiles 4 and 6 as the intermediate zone between layer 5f and 5g. Therefore, it is possible that this layer correlates with one of the facies described above.

B.2.15 Layers V6-1 and V6-2

Section: West

Archaeological level: 5g

Profiles: P4, P6, P51, P52

Complex V6 is one of the rare cases in which a sediment is found deprived of a fine-grained, micritic matrix. Layer V6-1 consists entirely of well-rounded littoral carbonate clastics and quartz sand. A pedogenic process which left behind numerous calcified root cells, clay accumulation in pores and iron coatings around particles occurred after the colluviation of carbonate clastics. Iron oxidation is responsible for the distinct orange color of complex V6. Differentiation of level V6-1 and V6-2 was made on the basis of calcite proportions being higher in the lower part.

B.2.16 Layers V7-1, V7-2, V7-3, and V7-4

Section: West

Archaeological level: none

Profiles: P27(?), P44, P45, P51, P52

This LCD-AV facies sequence was identified in trench W3 as being located between layers 5f and 5g which were documented in adjacent profiles 4 and 6 in 1999. The whole sequence attains 50cm and was truncated by the deformation of overlying complexes V6, V5, and V4. This explains why complex V7 was not recognizable in 1999. At least two detrital carbonate mud layers (V7-1 and V7-3) are intercalated with two olive green clay beds of which the lower one, layer V7-4, is the thickest of this type found in the Mousterian sequence (Fig.22). Except for layer V7-2, complex V7 was not sampled for sedimentological analysis yet. Layer V7-2 is a carbonate-clay deposit containing around 10% quartz sand, a high proportion of gypsum and a few gastropod shells. Some of the quartz particles exhibit a glossy surface which is caused by a secondary accretion of SiO_2 in an alkaline milieu. The clay facies' depositional environment was probably composed of a perennial lake with changing pH values. Dry periods caused a decrease in carbonate precipitation and increase in pH value which in turn triggered the neoformation of smectite (Meyer 2001). In addition, Aeolian sand accumulated. Transgression phases, in turn, favored the precipitation of carbonates and the presence of aquatic fauna, such as gastropods. However, transgressions of the water table must have been rapid and of low scale, as no pure freshwater carbonates are associated with these clay accumulations. For the moment, we assume an arid climate phase to be responsible for the deposition of complex V7. This assumption is corroborated by the lack of archaeological remains meaning that humans avoided the region because of unfavorable conditions.

B.2.17 Layers V8-1 and V8-2

Section: West

Archaeological level: 5h

Profiles: P3, P4, P6, P7, P44, P45, P51, P52

Complex V8 is a massive, 180cm thick deposit which represents an in situ freshwater carbonate accumulation at its base, and several subsequent colluviation processes. A pedogenic horizon on the top of Hummalian level 6a was eroded due to turbulence caused by a major transgression phase in the course of which carbonate mud accumulated (Meyer 2001). The sterile freshwater carbonate is followed by several phases of resedimentation incorporating littoral carbonate clastics and other sorts of detritus. The corresponding LCD facies probably reflect a marshy environment which developed during the onset of long lasting arid period. Intensive weathering of littoral carbonates lead to an embedding of corresponding debris within the mud at the lake's base. A major collapse of the littoral zone is evidenced by a massive colluvium in layer V8-1. The carbonatic silt lacks any internal structure and clastics are irregularly aligned. Iron oxides, manganese accumulations and root traces are related to the pedogenic processes in layer V7-4.

B.3 The Pleistocene sequence in the southern section of Hummal

B.3.1 Layers S-V1-1, S-V1-2, S-V1-3, S-V1-4

Section: South

Archeological level: 5AI

Profiles: P58, P59, P63, P69, P70a, P71, P72

Layers S-V1-1 to S-V1-4 are the uppermost Pleistocene deposits in the southern section of Hummal and are described together because single layers do not extend over the whole excavated area. Observations made during the extension of profile P71 and in test pit S3 confirmed the presence of at least four deposits that can be designated as distinct layers. Definition and recognition of these deposits is hampered by the intensive weathering which affects the uppermost part of the sequence. As can be seen in the westernmost part of profile P71, layer S-V1 appears as a rather homogeneous grey to white colored carbonatic silt (Fig.24). Two meters to the east, at least three layers are distinguishable, namely layer S-V1-4 at the base and layer S-V1-3 which can be subdivided into two sub-layers. From point X=106 eastwards, two additional layers (S-V1-2 and S-V1-1) appear on top of layer S-V1-3 which were eroded before or during deposition of layer III and are hence no longer visible in the western half of the excavated area. These observations suggest that a major stratigraphical gap exists between the uppermost Pleistocene deposits and overlying Holocene colluvations. It is possible that parts of layer S-V1 and further deposits originally situated on top of it are found as a massive colluvium which was discovered more than 3m below in the well funnel (Fig.25).

Complex S-V1 is a massive, unconsolidated grey to white colored carbonate deposit. Compiled, it is over 90cm thick and shows a succession of carbonatic silts with varying amounts of detrital content interstratified with a clayey gypsum deposit (layer S-V1-2). The high amount of gypsum is explicable by the sediments’ constant aeration close to the modern surface. Intensive bioturbation and weathering, especially in the upper half of layer S-V1, caused a significant alteration of the original sediment texture. The sediment in layers S-V1-1 and S-V1-2 was not examined in detail, but observations made in the field suggest that the former is a detrital carbonate mud whereas the latter can be attributed to the palustrine type of freshwater carbonates. Underlying layers S-V1-3 and S-V1-4 are silt deposits consisting of two types of carbonate clastics with a grain-size below 1mm, namely cemented lake marl and travertinized, grey-colored littoral carbonates. Together, these small-grained elements comprise of more than 90% of the sediment. The mixture of angular and well-rounded grains suggests differential transport distances and hence a rather slow sedimentation rate. Remarkable is the presence of many small bone fragments with a size between one and two millimeters. They are displaced remnants stemming from larger pieces which were mechanically and chemically affected by wave attack and weathering.

The varying amounts of detritus and the presence of at least one immature soil formation indicate a rapidly changing water table. The massive carbonate deposits in layers S-V1-1 to S-V1-4 can be tentatively correlated with a prolonged humid period. Minor regressions lead to a sub-aerial exposure of littoral carbonates and the growth of vegetation (layer S-V1-2) or travertinization (base of layer SV1-4).

B.3.2 Layer S-V1-5

Section: South

Archeological level: 5AII

Profiles: P58, 59, P63, P68, P69, P70a, P71, P72

Layer S-V1-5 is a detrital, green-grey colored carbonate mud with a high amount of gypsum. It is clearly visible in profiles P69 and P71 and attains a variable thickness ranging from 2cm in the north-eastern part to over 30cm in the north-western part (Fig.24). In the eastern half of the excavated area layer S-V1-5 shows a steep gradient whereas further to the west it appears in a sub-horizontal position. For the moment, we can only speculate about the factors which were responsible for these changing inclinations. To be taken into account are varying intensities of erosion before or during deposition of overlying layer S-V1-4 and /or an uneven paleosurface allowing for different volumes of deposition.

Layer S-V1-5 belongs to the group of palustrine carbonates. Indicators of a dense vegetal cover are root traces and the precipitation of iron oxides and manganese. The fine-grained sediment consists mainly of small carbonate clastics with a size below 1mm (96%). They seem to have had different origins with angular locally weathered clastics occurring next to well-rounded particles which were transported over a considerable distance. Both sub-littoral and littoral varieties of carbonate can be found together with gastropod shell fragments and other biogenic minerals. Carbonate precipitation was followed by a lowering of the water table and sub-aerial exposure leading to a pedogenic modification of layer S-V1-5. Probably at this moment, humans occupied the littoral zone and left a considerable number of lithic artifacts and faunal remains. The majority of the latter are destroyed due to chemical and mechanical weathering.

B.3.3 Layer S-V1-6

Section: South

Archaeological level: 5AIII

Profiles: P58, P59, P63, P68, P69, P70, P71, P72

Layer S-V1-6 is massive beige-colored carbonatic silt deposit which was located in all excavated sections. With a mean thickness of 60cm it is one the most extensively developed lacustrine carbonate formations in the southern section. The irregular gradient visible at its upper and lower limit is a result of erosion processes that occurred before and after the deposition of layer S-V1-6 (Fig.24). Based on differential amount of detritus and compaction, the layer can be subdivided into three sub-layers, namely S-V1-6-1, S-V1-6-2, and S-V1-6-3. The uppermost sub-layer S-V1-6-1 is a 20cm thick travertinized lacustrine carbonate which was not sampled for sedimentological analysis. Underlying sub-layer S-V1-6-2 is a 25cm thick detrital deposit which is mainly composed of polygonal-shaped travertine clastics. Nevertheless, the proportion of small-sized particles with a size below 1mm is significant (83%) and is principally comprised of micrite attributable to the *Seekreide*-type and grey-colored, travertinized carbonate clastics stemming from the littoral zone. These carbonate clastics are only slightly rounded indicating minor transport distances and a rapid sedimentation rate. A further constituent are quartz grains of which some exhibit a glossy, rounded surface and can be seen as authigenic products. Striking is the absence of organic components. Sub-layer S-V1-6-3 is identified as a thin bed of large-sized carbonate clastics with a mean diameter of 5cm.

Carbonate precipitation occurred during a generally high but oscillating water level. During regression phases, wind-blown material accumulated and the weathering of littoral carbonates set on. A few lithic artifacts were found vertically dispersed all over the deposit. The lack of a distinct concentration suggests that displaced objects stemming from the nearby lake margin accumulated in the sub-littoral zone where water flows caused their irregular alignment.

B.3.4 Layer S-V1-7

Section: South

Archaeological level: 5AIV

Profiles: P58, P59, P63, P68, P69, P70b, P71, P72

Layer S-V1-7 is a detrital carbonate mud showing pedological features. It was identified only in the western half of the southern section, and the irregular gradient seems to reflect sedimentation in shallow depressions which can be the result of either subsidence effects and/or differing intensities of erosion (Fig.24). The thickness of layer S-V1-7 is variable with a minimum of 3cm and a maximum of 20cm. The sediment consists of a carbonate enriched in clay, gypsum and quartz sand which appears as a thin concentration at the level's base. Granulometric analysis reveals a high concentration of elements with a grain-size below 1mm (85%) and a significant amount of large-grained elements with a size above 2mm (10%). The latter are mainly polygonal-shaped gypsum crystals. The fine-grained constituents comprise rounded clastics of carbonate conglomerates, the origin of which is unknown. Likely, the quartz grains are well-rounded with a matt surface, indicating aeolian transport.

Layer S-V1-7 is tentatively attributed to the palustrine-type of carbonates which were intensively modified by pedogenesis. Layer formation presumably occurred in brackish, oxygen-depleted water. The deposit's greenish color is a result of suspended redox reactions in these reducing conditions. Prior to the pedogenic process, wind-blown quartz sand accumulated during a marked dry period. A dense concentration of lithic artifacts has been recorded in layer S-V1-7. The correlation of archaeological material with palustrine carbonate deposits is a recurring phenomenon in the Mousterian sequence of Hummal. Due to its high density of findings, layer S-V1-7 is one of the most illustrative examples.

B.3.5 Layer S-V1-8

Section: South

Archaeological level: 5AV

Profiles: P58, P59, P63, P68, P69, P70b, P71, P75

Layer S-V1-8 is an unstructured, detrital carbonate mud that stretches all over the excavated area with a varying thickness ranging from 10 to 60cm (Fig.24). The soil formation in overlaying layer S-V1-7 caused a reworking of the sediment through bioturbation. The principal constituents are fine-grained carbonate clastics. Some of them belong to lake marl from the sublittoral zone, others are weathered littoral carbonates. Remarkable is the absence of quartz sand when one regards the overlying base of level S-V1-7, which is largely composed of this material.

The context of deposition can be reconstructed as a period during which an anoxic, shallow water body prevailed. However, the low amount of terrestrial material indicates that the regression phase was of a short duration and minor scale. At one point in time, carbonate precipitation stopped due to an interrupt in freshwater supply. A dry climate probably caused the water level to drop significantly whereby the littoral zone was sub-aerially exposed and the weathering of littoral carbonates set on. Layer S-V1-8 revealed some lithic artifacts but no faunal remains which were presumably not preserved in these unfavorable conditions.

B.3.6 Layer S-V1-9

Section: South

Profiles: P71

Layer S-V1-9 is presumably an eroded soil formation which is identifiable at the eastern extremity of profile P71, in area X=107 to X=107.5. The sediment consists of dark-colored carbonate-clay mixture. It is unclear whether this accumulation of fine-grained material is actually a true layer or represents vertically displaced clay particles along fissures. Layer S-V1-9 was not analyzed in detail and therefore this question will only be solved by a comparison of layer S-V1-9 with the overlying soil formation in layer S-V1-7.

B.3.7 Layer S-V1-10

Section: South

Profiles: P71

Layer S-V1-10 is located directly below the palustrine carbonate deposit S-V1-9. It is composed of carbonate silt with a color ranging from brown to orange. The lower limit of layer S-V1-10 was not reached during excavation of trench S2, and therefore, it’s vertical as well as horizontal extension is unknown. It seems that only a small remnant of an originally more extended deposit is left because layer S-V1-10 was not identifiable in adjacent trench S3. Layer S-V1-10 was not sampled for sedimentological analysis. Moreover, as it was not recognized during excavation of trench S2 it is unclear whether there exists any correlation with archaeological remains.

B.3.8 Layer S-V1-11

Section: South

Archaeological level: 5AVI

Profiles: P58, P59, P63, P71

In trench S1 layer S-V1-11 was encountered as 30cm thick travertine deposit containing a high amount of detritus. The travertine shows a decreasing thickness in its eastern extension and is finally no more visible from point X=110 onwards (Fig.24). It is unclear whether travertinization occurred only in this area or was seriously affected by weathering.

The strong compaction of layer S-V1-11 impedes a grain-size analysis and a detailed investigation of its structure and composition is only possible with thin sections. The sharp limit to underlying layer S-V2-1 can presumably be seen as an evidence for a complete hold-up of source activity. Subsequently, sedimentation and travertinization started again under shallow water. This is the reason why level S-V1-11 is currently attributed to complex S-V1 despite the fact that the travertine formation also warrants a correlation with underlying complex S-V2. Artifacts were principally found in the range of trench S1 and some isolated finds appeared in adjacent sections to the east.

B.3.9 Layer S-V2-1

Section: South

Archeological level: 5BI

Profiles: P58, P59, P63, P68, P69, P70b, P71, P75

Definition of layer S-V2-1 still faces considerable problems as the sediment’s structure is varying over the excavated area. In trench S3 it is encountered as unconsolidated carbonatic silt with a low amount of detritus, whereas in the west, it appears as a travertinized carbonate deposit. Its thickness is around 10 to 15cm. A common feature is the absence of root cracks, iron oxides and manganese precipitation.

It is assumed that deposition and subsequent travertinization of layer S-V2-1 occurred during a short time-span. Carbonate precipitation and travertine formation occurred at the edge of a shallow lake. It is possible that layer S-V2-1 in trench S3 accumulated further away from the lake margin under a higher water table and therefore underwent no travertinization. An enlargement of trench S3 and new adjacent trenches will give new insights into the paleotopographical situation and thereby help to better define the depositional context of level S-V2-1.

B.3.10 Layer S-V2-2

Section: South

Archaeological level: 5BII

Profiles: P58, P59, P63, P68, P69, P70, P71, P75

Beneath the travertine in layer S-V2-1 a detrital carbonate mud appeared which represents a sedimentation process under water. Its thickness varies between 3 and 17 cm (Fig.24). The limit between layer S-V2-2 and overlying layer S-V2-1 is diffuse and identifiable only on the basis of slight variations in compactness and detritus. The latter comprises many gastropod shells, ostracods and calcified remains of *Characea*. Other typical features are manganese concentrations, iron oxides and the fenestral fabric formed by root traces. Post-depositional travertinization caused a significant cementation in the upper part of layer S-V2-2 making it difficult to excavate. The lower part, on the other hand, shows a porous fabric and is slightly weathered. Granulometry shows that the sediment mainly consists of fine-grained elements with a size below 1 mm, such as small carbonate and travertine fragments. Their surface is markedly rounded and coated with iron oxides. The proportion of quartz sand is low and comprises neo-formed crystals next to allochthonous material.

It is assumed that layer S-V2-2 was deposited in an ephemeral lake surrounded by a dense vegetation cover. Travertine formation was probably induced by photosynthesis of microorganisms and algae. It is possible that the upper part of layer S-V2-2 was rearranged during the deposition of layer S-V2-2. Layer S-V2-2 contains lithic artifacts and poorly preserved faunal remains. As the lithics show no signs of edge damage and a clear-cut concentration of findings is lacking, it can be assumed that the objects were slightly displaced and sorted by wave attack.

B.3.11 Layer S-V2-3

Section: South

Archaeological level: 5BIII

Profiles: P58, P59, P63, P71, P75

Layer S-V2-3 is a travertinized detrital mud with a varying thickness between 8 and 20cm (Fig.24). The transition to overlying layer S-V2-2 is diffuse whereas a clear-cut erosive gap is present at the lower contact zone to sediment complex S-V3. The major component is a fine-grained micrite incorporating a high density of gastropods and ostracods. A recurrently changing water table triggered the travertinization and alteration of level S-V2-3 as well as the input of terrestric material. The intensive oxidation of irons and manganese is an indication that the sediment was frequently exposed to aeration. Local variation in compactness shows that some areas were more durably covered by water than others.

The model of deposition for layer S-V2-3 is as follows: In the earliest phase, a fine-grained carbonate mud accumulated at the basin of a deep, low-energy lake basin. Carbonate precipitation was stopped by a sudden and marked drop-down of the water level. Subsequent desiccation significantly modified the sediment and aeolian material was blown in. The arid phase was followed by more humid conditions which saw short-term fluctuations of the water table and renewed alteration of the remaining carbonate substrate. It is unclear at which moment in the deposition process humans left their waste at the littoral zone.

B.3.12 Layer S-V3-1

Section: South

Archaeological level: none

Profiles: P58, P59, P63

The top of sediment complex S-V3, which was identified in trench S1, is composed of compacted, sterile freshwater carbonate. With a thickness of about 30cm it seems to represent an uninterrupted process of carbonate precipitation which occurred after a considerable rise of the water level. Layer S-V3-1 was not analyzed in detail, and therefore no further information is available regarding the sediment’s texture and composition. The 2009 surface excavation ended at the transition between layer S-V2-3 and layer S-V3-1 which appears gradual suggesting that no major erosion took place.

B.3.13 Layer S-V3-2

Section: South

Archaeological level: 5DII

Profiles: P58, P59, P63

Layer S-V3-2 appeared as a thin carbonate accumulation including a moderate amount of detritus. A concentration of clay minerals, which are possible pedological traces, was found at its base. In contrast to layer S-V3-1 sedimentation probably occurred in a shallow lake where the formation of travertine was triggered by aquatic plants thriving at the lake margin. The carbonate mud accumulated on top of an immature soil which probably developed during a short dry period. Only two lithic artifacts and one bone were found in layer S-V3-2 and regarding their vertical distribution, it is possible that they represent displaced objects in the course of post-depositional diagenesis.

B.3.14 Layer S-V3-3

Section: South

Archaeological level: none

Profiles: P58, 59, 63

An increase in detritus quantity marks the limit between layer S-V3-2 and layer S-V3-3. The latter was found as cemented, white-colored carbonate silt which can be differentiated into three sub-layers on the basis of differing amounts of detritus. High amounts are found at the top and at its base. Layer S-V3-3 was not analyzed in detail, but it can be assumed that carbonate precipitation occurred in the context of a high water table which faced only minor oscillations. Regression phases are coupled with an input of detrital material, whereas transgression phases are correlated with a pure freshwater carbonate. This interpretation coincides well with the absence of archaeological material. Increased spring activity either did not allow for a settlement in the vicinity of the source or the place of occupation is located outside of the excavated area due to the lake's extension.

B.3.15 Layer S-V3-4

Section: South

Archaeological level: 5DIV

Profiles: P58, 59, 63

Layer S-V3-4 is a massive, 25cm thick carbonate mud that contains a low amount of detritus. It was identified as a laminated deposit due to the presence of thin light grey and dark grey colored laminae which can be distinguished by differently sized calcite crystals (Meyer 2001, 35; Hager 2008, 77)). The sediment matrix appears compacted with a low porosity. Limnic elements, such as oogones, calcified remains of *Characea*, gastropods, and ostracods are present. Negatives of root cells can tentatively be correlated with the pedogenic alteration of overlying layer S-V3-2. Ferruginous coatings around carbonate and sand particles as well as small concretions found in pores indicate episodes of waterlogging and subsequent desiccation. Another remarkable feature of layer S-V3-4 is the presence of minuscule charcoal tinsels and carbonized vegetal remains.

Layer S-V3-4 probably represents an uninterrupted sedimentation process in a rather calm milieu. The lamination of the fresh water carbonate suggests that accumulation occurred in the littoral zone and was influenced by a seasonal fluctuation of the water table. A few archaeological remains were unearthed and considering the depositional context of layer S-V3-4, they can be seen as dislocated items which were moved in by water flow.

B.3.16 Layer S-V3-5

Section: South

Archaeological level: 5DV

Profiles: P58, 59, 63

The base of complex S-V3 is formed by a thin layer of carbonatic silt which was distinguished in the field from layer S-V3-4 on the basis of an increasing quantity of detritus. However, micromorphological analysis does not corroborate this differentiation except for the fact that a higher amount of gastropods is discernable (Hager 2008, 166). As for layer S-V3-4, the deposit can be attributed to the laminated type of carbonate mud showing a low porosity and high density of limnic elements, such as gastropods, stems of *Characea*, oogones, and ostracods. Coatings of iron oxides occur frequently at the base of level S-V3-5 and indicate an intensified redox reaction. The sediment is primarily composed of small-grained and well-rounded carbonate and quartz particles which can be seen as allochthonous, aeolian elements.

Layer S-V3-5 was deposited in the same environmental context as was proposed for overlying layer S-V3-4. Principally, sedimentation was governed by transgressions of the water level. Nevertheless, precipitation of gypsum and iron oxides indicate intermittent regressions, and it is assumed that these oscillations of water content are related to seasonality. The high density of archaeological remains can either be correlated with a distinct occupation or with a vertical displacement of objects from underlying level S-V4.

B.3.17 Layer S-V4

Section: South

Archaeological level: 5E

Profiles: P58, P59, P63

Level V4 is a clearly distinguishable deposit due to its matrix and content. It has been interpreted as littoral sand facies that has nowhere else been found in Hummal yet (Hager 2008). A major feature is the abundance of gastropods and therefore, the 15 to 20cm thick layer resembles gastropod sand. The sediment is unconsolidated and contains a considerable portion (46%) of large-grained constituents, such as travertine fragments, carbonate and conglomerate clastics. Most common are carbonatic medium sands (40-70%); the proportion of quartz sand is between 10% and 20%. The sediment texture is unconsolidated with a high porosity of 20 to 40%. Typical constituents are limnic elements, such as gastropods, remains of *Characea*, oogones, and ostracodes, whereas terrestrial components are rare. Referable to anthropogenic activity are small bone fragments and flitters of charcoal.

In the northern part of trench S1 (after Y=14), layer S-V4 shows three sub-layers. A two to three centimeter thick littoral sand deposit (layer S-V4-1) is followed by a laminated carbonate mud (S-V4-2) which overlays a five centimeter thick littoral sand (S-V4-3) displaying the same composition and texture as layer S-V4-1. In the southern half of trench S1 the intermediate carbonatic silt is missing probably due to an erosion process during the deposition of layer S-V4-1. The existence of a laminated carbonate mud between two littoral sand deposits suggests a marked oscillation of the water level. Changes in the redox potential are further indicated by intensive precipitation of iron oxides. As the gastropods are mainly undamaged, sand accumulation took place during short-term low energy transgressions of the lake's shoreline (Hager 2008). Contrastingly, the sedimentological analysis suggests a high-energy depositional context during which material in suspension did not accumulate. This assumption is based on the angular sphericity of particles and absence of micrite. While the question concerning sedimentational dynamics remains unclear, it seems evident that layer S-V4 was rapidly deposited in the context of a seasonal fluctuation of the groundwater outlet. The littoral sands were then rapidly overlain by fine-grained carbonatic silt which protected organic and archaeological remains. The latter are abundant, and it can be assumed that hominids occupied the beach-like deposit at least two times.

B.3.18 Layer S-V5-1

Section: South

Archaeological level: 5FI

Profiles: P58, P59, P63

Layer S-V5-1 is a black colored clay deposit with a mean thickness of 10cm. Its upper part was eroded during the deposition of the overlying littoral sand. The texture shows the typical sub-angular blocky structure which is caused by desiccation and which is a typical feature of all fine-grained sediments in Hummal (Meyer 2001, 41). The dominant type of clay mineral in layer S-V5-1 and all other clay deposits of Hummal is smectite. It is found together with littoral sand from overlaying layer S-V4 which accumulated in fissures in the contact zone. Two sedimentological features are remarkable: a relatively high proportion of quartz sand and a significant density of organic remains in various forms, such as thin organic levels, carbonized vegetal remains, and small bone fragments (Hager 2008). The quartz sand represents an accumulation of wind-blown material, whereas the organic material is the remainder of decayed local vegetation. Another typical feature is iron oxide coatings around particles.

The presence of smectite, aeolian constitutents and iron oxide precipitation indicate a prolonged exposal of the deposit to arid conditions and a slow sedimentation rate. Layer S-V5-1 is probably related to a *sabkha*-formation during which the site was a closed basin and evaporation played an important role in the depositional context (Meyer 2001). This interpretation is further corroborated by the discovery of heavily patinated and edge damaged artifacts which were exposed for a long time on an open surface.

B.3.19 Layer S-V5-2

Section: South

Archaeological level: 5FII

Profiles: P58, P59, P63

The sedimentological composition of layer S-V5-2 suggests that deposition occurred in the context of an extended lake system. The deposit is a pure, *in situ* freshwater carbonate which accumulated in the shallow littoral zone (Hager 2008). Detritus is found in fissures which were caused by post-depositional desiccation. The sediment's matrix consists of thin levels of grey to green colored micrite with local inclusions of quartz and gypsum crystals. Granulometric analysis shows that the fine-sand-silt fraction is clearly dominating (98%). Liminic elements are present however in low quantity as are iron oxide concretions.

Deposition of this type of carbonate mud occurred very quickly, and consequently, the potential for aeolian infill was limited (Hager 2008; Meyer 2001). The few artifacts found in layer S-V5-2 are not *in situ* and the palimpsest level 5FII is probably composed of dislocated objects from the adjacent terrestrial zone.

B.3.20 Layer S-V5-3

Section: South

Archaeological level: none

Profiles: P58, P59, P63

Showing a diffuse and non-erosive transition to the overlaying carbonate mud, the carbonatic silt found in layer S-V5-3 can be related to a transgression of the water table. It exhibits a laminated texture composed of brown and grey colored carbonates and consists mainly of fine-grained elements (89%). As such it resembles the varve-like deposit found at the base of complex S-V3. A high water level is further indicated by the presence of limnic elements (ostracods, gastropods) and lake marl clastics, and the absence of aeolian sand in the sampled section speaks in favor of a rapid accumulation. However, observations made in the field rather suggest a sedimentation process in the context of an oscillating water level. Grey colored littoral carbonates seem to intercalate with sub-littoral carbonate mud, and locally, small concentrations of quartz sand were discernable. While the precise depositional context of layer S-V5-3 remains unclear, it seems reasonable to assume a relatively short-term sedimentation process governed by seasonal fluctuations of groundwater outlet.

B.3.21 Layer S-V5-4

Section: South

Archaeological level: 5FIV

Profiles: P58, P59, P63

Similar to overlying layer S-V5-3, the carbonatic silt found in layer S-V5-4 shows a laminated structure composed of fine light brown to dark colored laminae. The 25cm thick deposit is heavily cemented and was therefore not sampled for a detailed analysis yet. Thus, it is not possible to determine whether the travertine formation was triggered by microbial activity or chemical processes. The laminated structure indicates short-term fluctuations of the shore-line probably related to seasonal changes of spring activity. Layer S-V5-4 was deposited in unconformity over the clayey silt in underlying layer S-V5-5 and probably eroded a significant part of it. Erosion seems to be related to one or several channels which can be seen in the southern part of trench S1. It is possible that these channels were created by dissolution affecting the carbonate substrate.

Because of the lack of detailed sedimentological data, the depositional context of layer S-V5-4 remains unclear. The varve-like sediment suggests a rather rapid sedimentation under a significant water cover.

B.3.22 Layer S-V5-5

Section: South

Archaeological level: 5FV

Profiles: P58, P59, P63

The top of layer S-V5-5 was eroded and subsequent depressions were filled by the carbonatic silt found in overlying layer S-V5-4. Thus, an irregular gradient and thickness are visible in profile 59 (Fig.25). Layer S-V5-5 can be designated as a clay-carbonate-mixture with a high proportion of fine-grained elements, such as slightly rounded and angular carbonate and travertine clastics (98%). In addition, well-rounded quartz particles exhibiting a matt surface are present and can be interpreted as allochthonous, aeolian constituents. Remarkable is the detection of microfaunal and vegetal remains.

The sedimentation process seems to be complex. For the present state of analysis, it is assumed that the clay content evidences an initial *sabkha* period during which a marshy environment prevailed. Increasing desiccation caused an intensive weathering and subsequent erosion of littoral carbonates and travertine, of which the clastics were mixed with clay. Finally, the sediment was further altered by a pedogenesis and bioturbation caused by small rodents. The major part of this soil formation was later destroyed by erosion. The few archaeological remains found in layer S-V5-5 are probably related with the pedogenic horizon, and as a marked difference in patination and severe edge damage are visible on lithic artifacts, it can be assumed that this surface was sub-aerially exposed for an extended period.

B.3.23 Layer S-V5-6

Section: South

Archaeological level: 5FVI

Profiles: P58, P59, P63

As one of the thickest layers in complex S-V5, layer S-V5-6 presumably represents a rather long, low-energy sedimentation process. The 50 to 60cm thick detrital mud shows several phases of detritus accumulation. It is mainly composed of fine-grained elements with a size below 1mm (99%), of which well-rounded carbonate clastics are the most frequent components. The presence of gastropods indicates a limnic environment. Despite the assumption of a long-term sedimentation process, aeolian constituents are absent; this observation leads us to the question whether layer S-V5-6 represents a major humid climatic phase during which dense and stable vegetation prevailed in the region, and thus, aeolian sedimentation became insignificant. Stable humid conditions could have correlated with a major extension of the source forming a deep lake. In this context, fresh water carbonate precipitation was the dominant form of sedimentation, and the changing amounts of detritus could evidence minor seasonal fluctuations of the water table.

The littoral zone was presumably occupied by humans; however, in the excavated area only displaced remains (level 5FVI) were identified as a palimpsest.

B.3.24 Layer S-V5-7

Section: South

Archaeological level: 5FVII

Profiles: P58, P59, P63

Layer S-V5-7 is the lowermost deposit of the southern Mousterian sequence. It is found in disconformity over the uppermost layer of the Hummalian complex (VI) and probably eroded a significant part of the latter (Fig.24 and Fig.25). The deposit shows a complex alternation between light-brown colored carbonatic silt and dark clay concentrations. The latter are found in at least three sub-horizontal beds with a thickness ranging from 2 to 6cm. Granulometric analysis reveals that the sediment is mainly composed of fine-grained elements with about 50% having a size below 0.25mm (silt, clay); additional constituents are gastropod fragments and a considerable proportion of quartz sand. Most of them can be referred to aeolian transport, but some exhibit a well-rounded form and glossy surface; these features indicate a secondary SiO_2 accretion which probably occurred due to changing pH values in the spring lake.

The depositional context seems to have been influenced by marked oscillations of the water table which however remained generally low. The alternation of clay deposits, aeolian components and freshwater carbonates presumably accumulated within an ephemeral lake; at times, transgressions occurred and an oxygen-rich milieu allowed for the precipitation of freshwater carbonate and the growth of aquatic plants; successive regressions on the other hand lead to the development of a marshy environment and increase in aeolian sedimentation. It is impossible to correlate the few archaeological remains found in layer S-V5-7 with a specific sub-facies, and we assume that they represent dislocated items which were moved during transgression phases.

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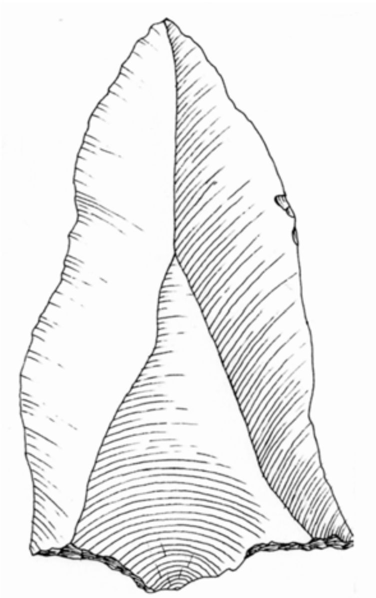
The Mousterian Sequence of Hummal (Syria)



Tables and Figures

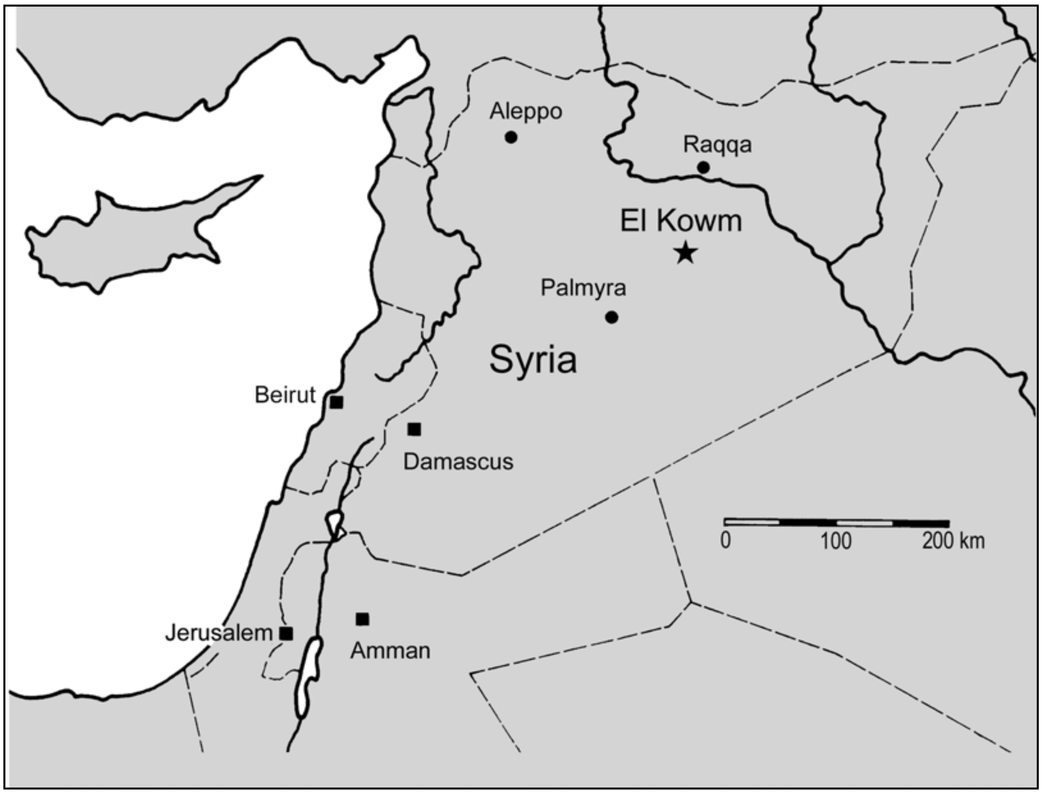


Fig.1: Map showing the location of El Kowm in Central Syria.

Fig.1

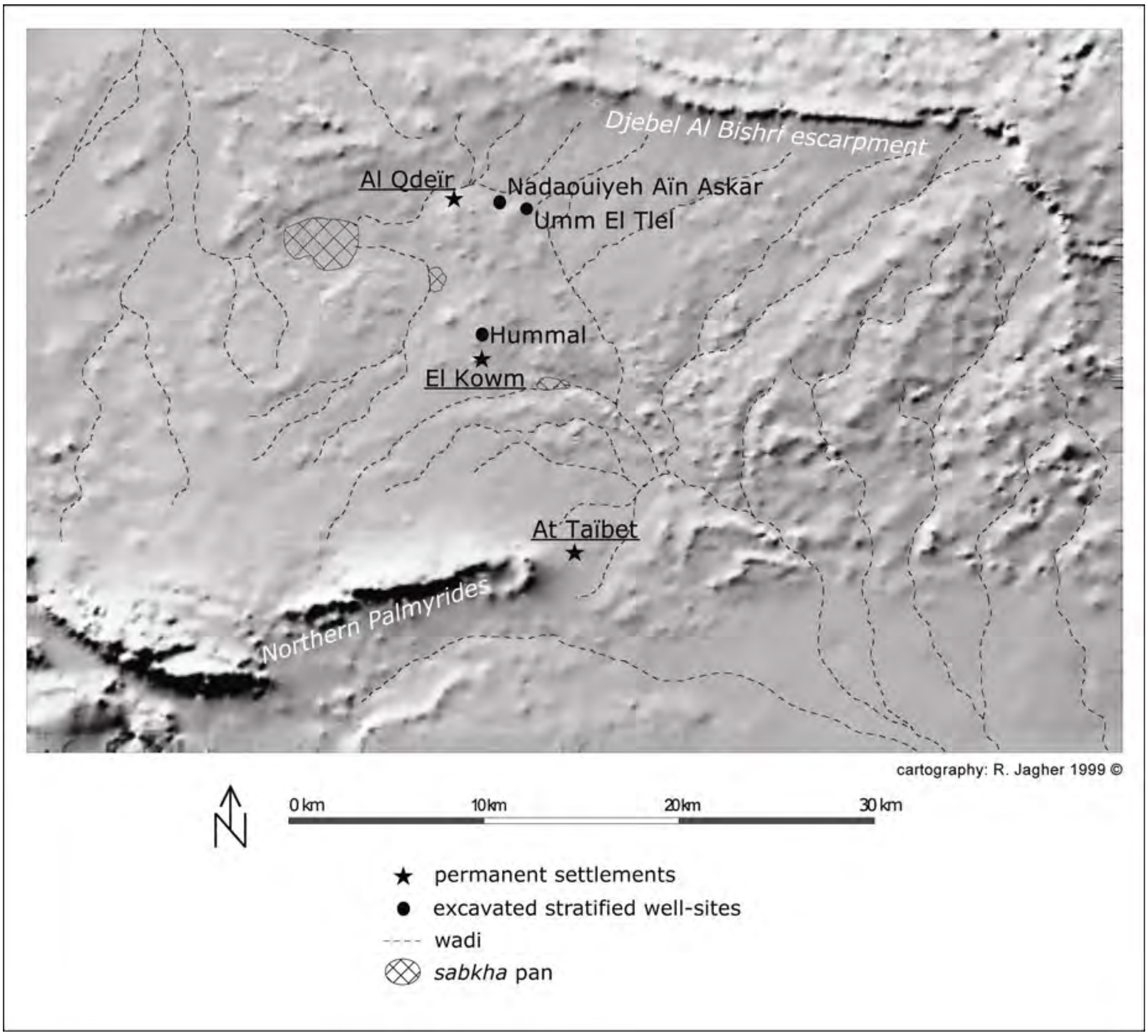


Fig.2: Topographical map showing the El Kowm region.

Fig.2

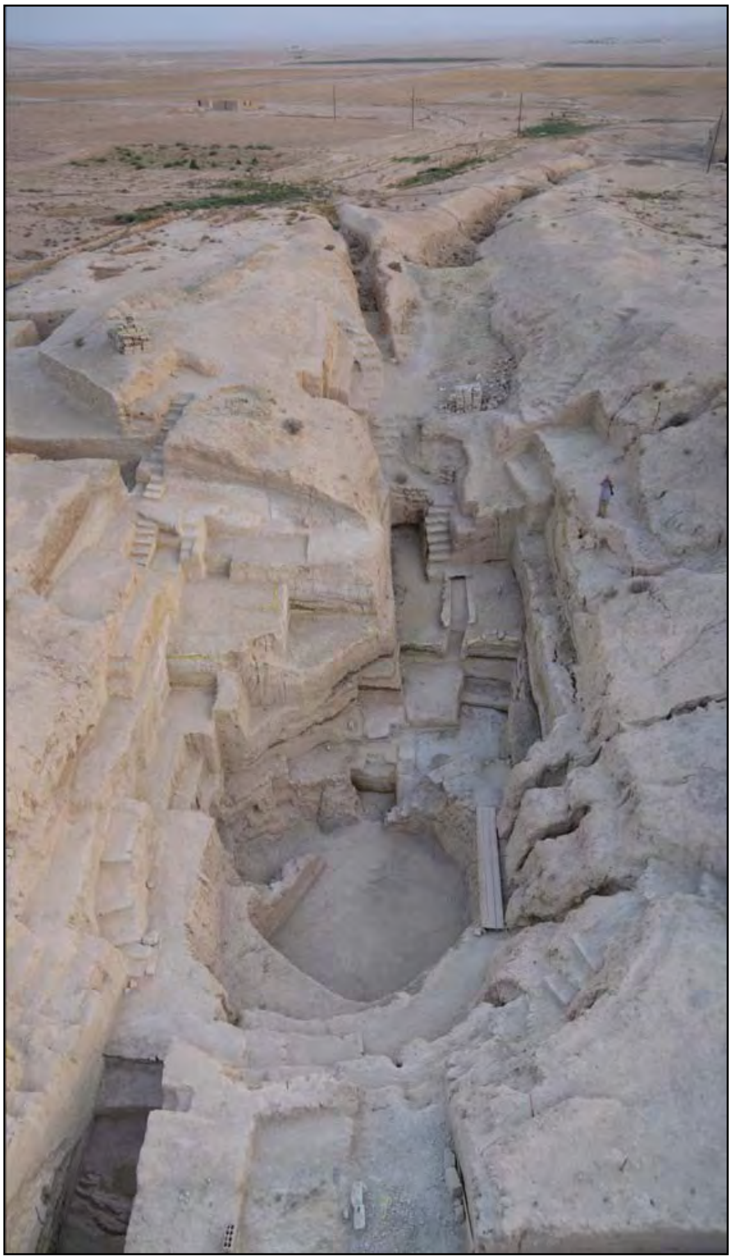


Fig.3: Excavation of Hummal: state of the art in 2008. The western section is visible in the left half, the southern trench S1 and adjacent excavation surface D is visible at the bottom. Note the circular structure of the remaining well shaft construction in the center of Hummal (photo taken by A. Sanson).

Fig.3

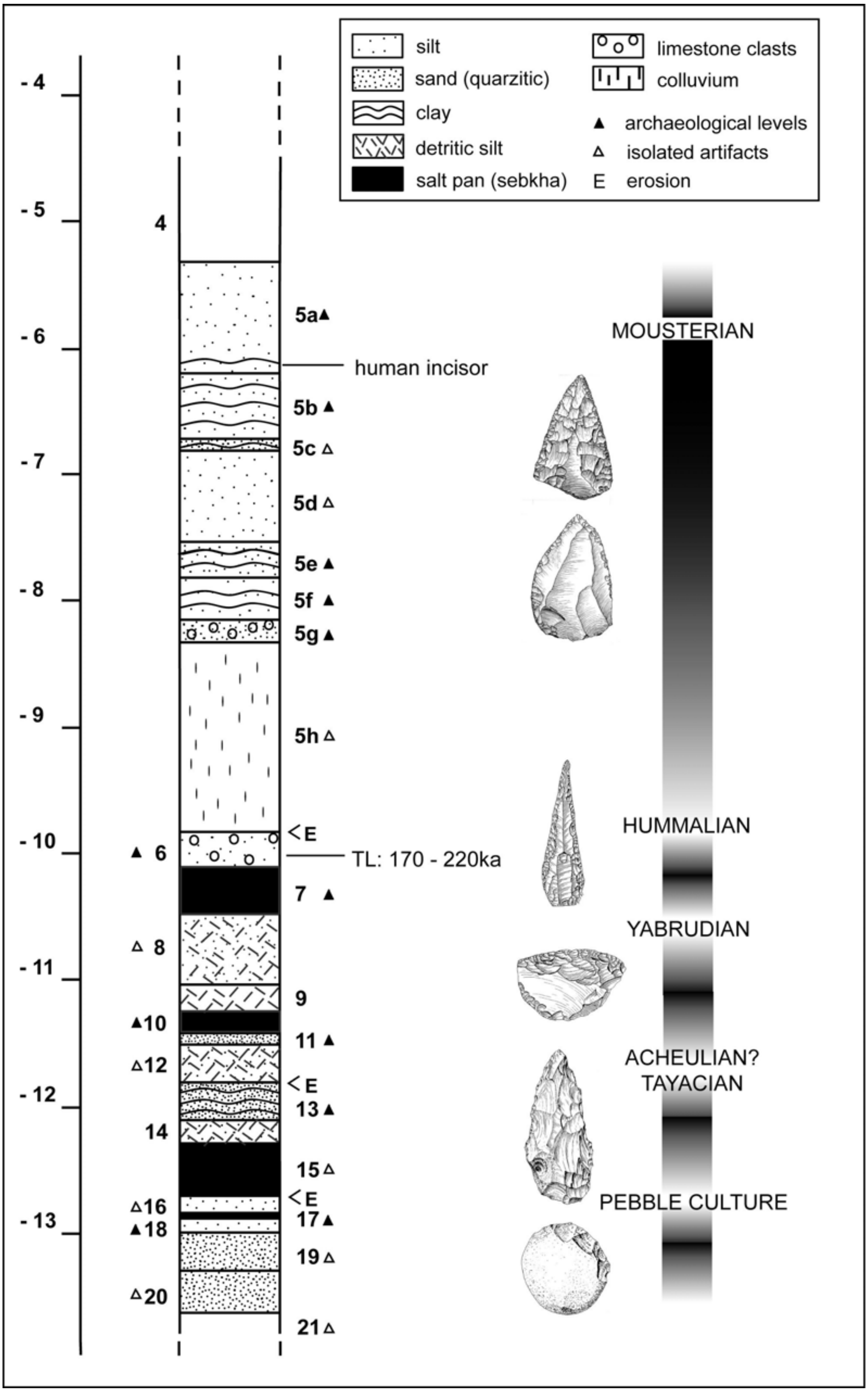


Fig.4: Synopsis of the archaeological sequence in the well-site of Hummal.

Fig.4

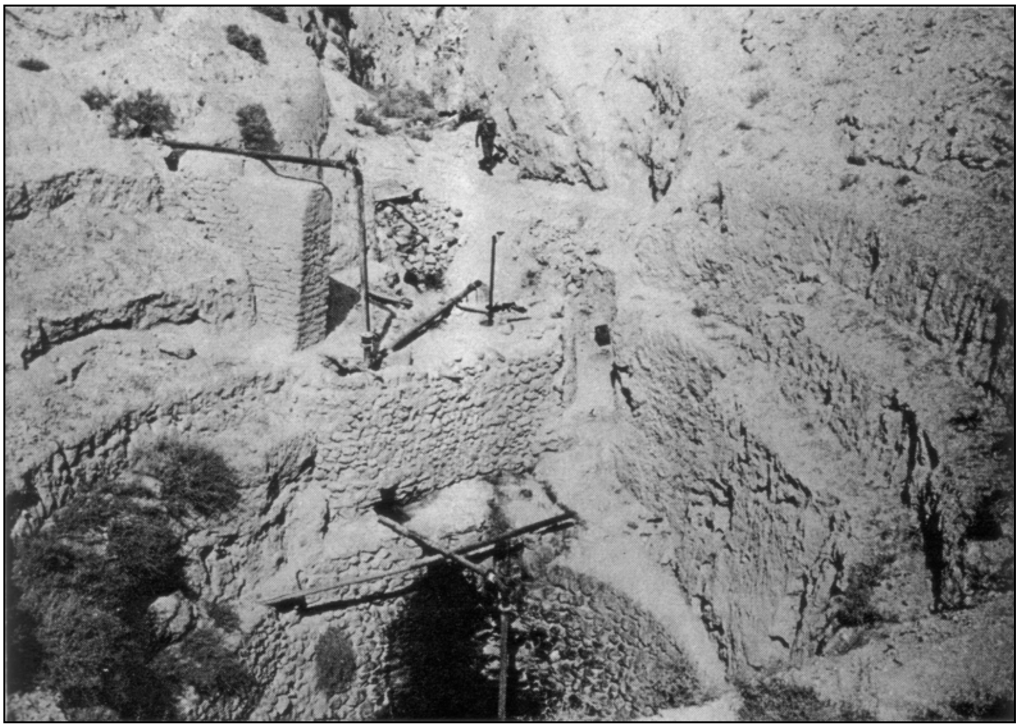


Fig.5: The well of Hummal in 1967. The photo which was taken by the Japanese mission (Suzuki et al. 1970) shows the northern half of the funnel.

Fig.5

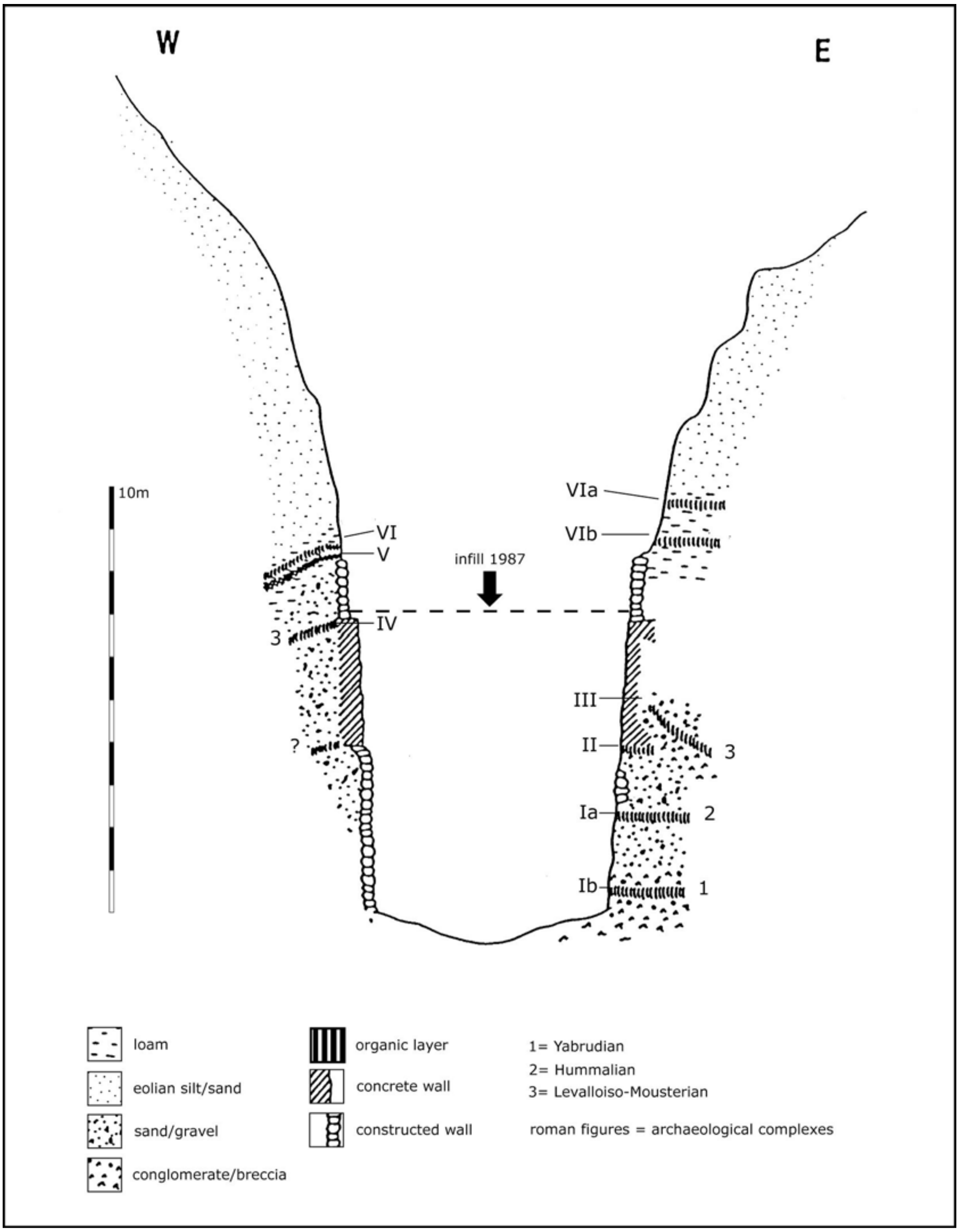


Fig.6: Cross section of the Hummal well with major depositional and archaeological complexes as seen in 1983.

Fig.6

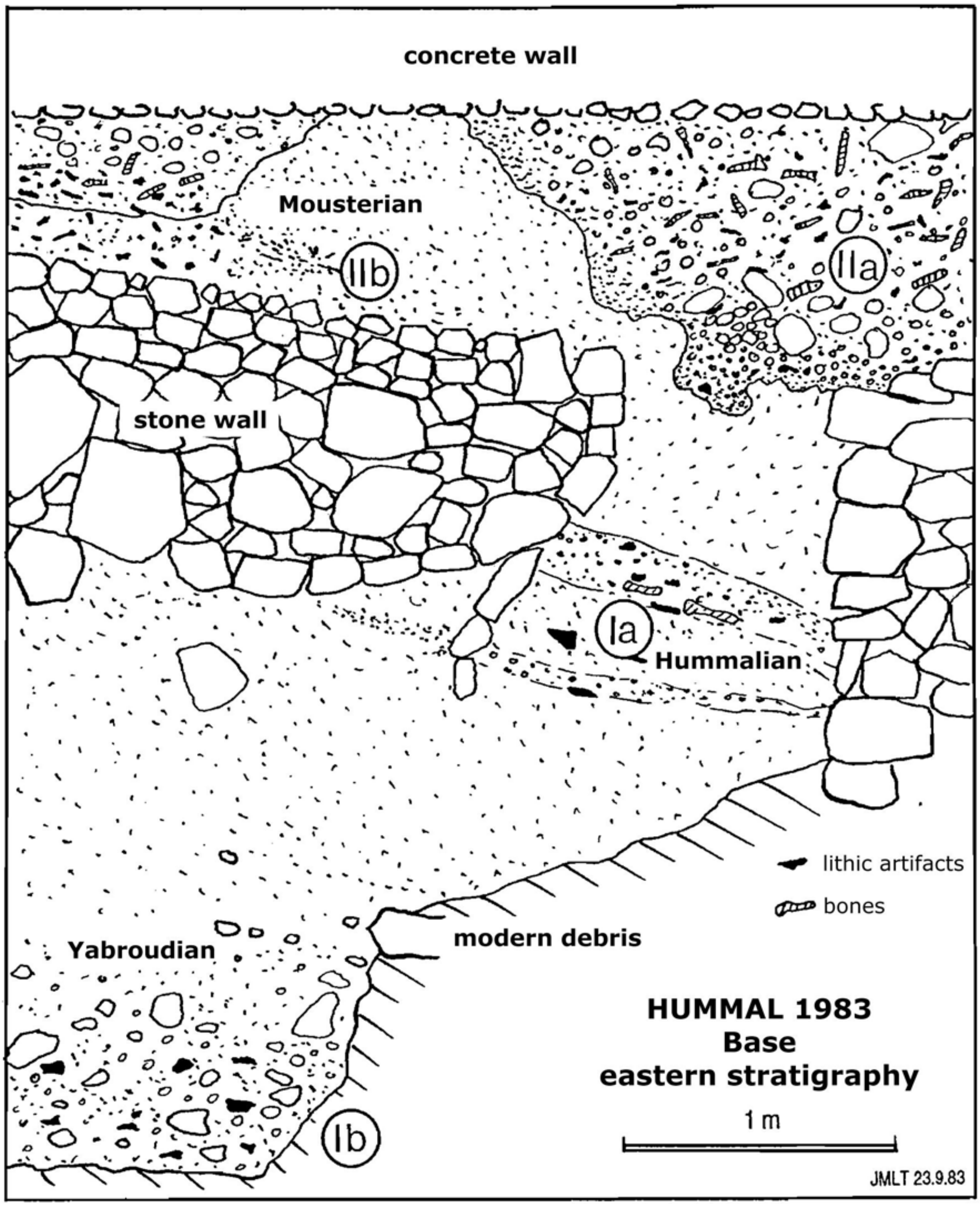


Fig.7: Profile 1 showing the displaced Hummalian (Ia), Yabrudian (Ib) and Mousterian (IIb) deposits at the bottom of the well (after Le Tensorer 2004, Fig.5).

Fig.7

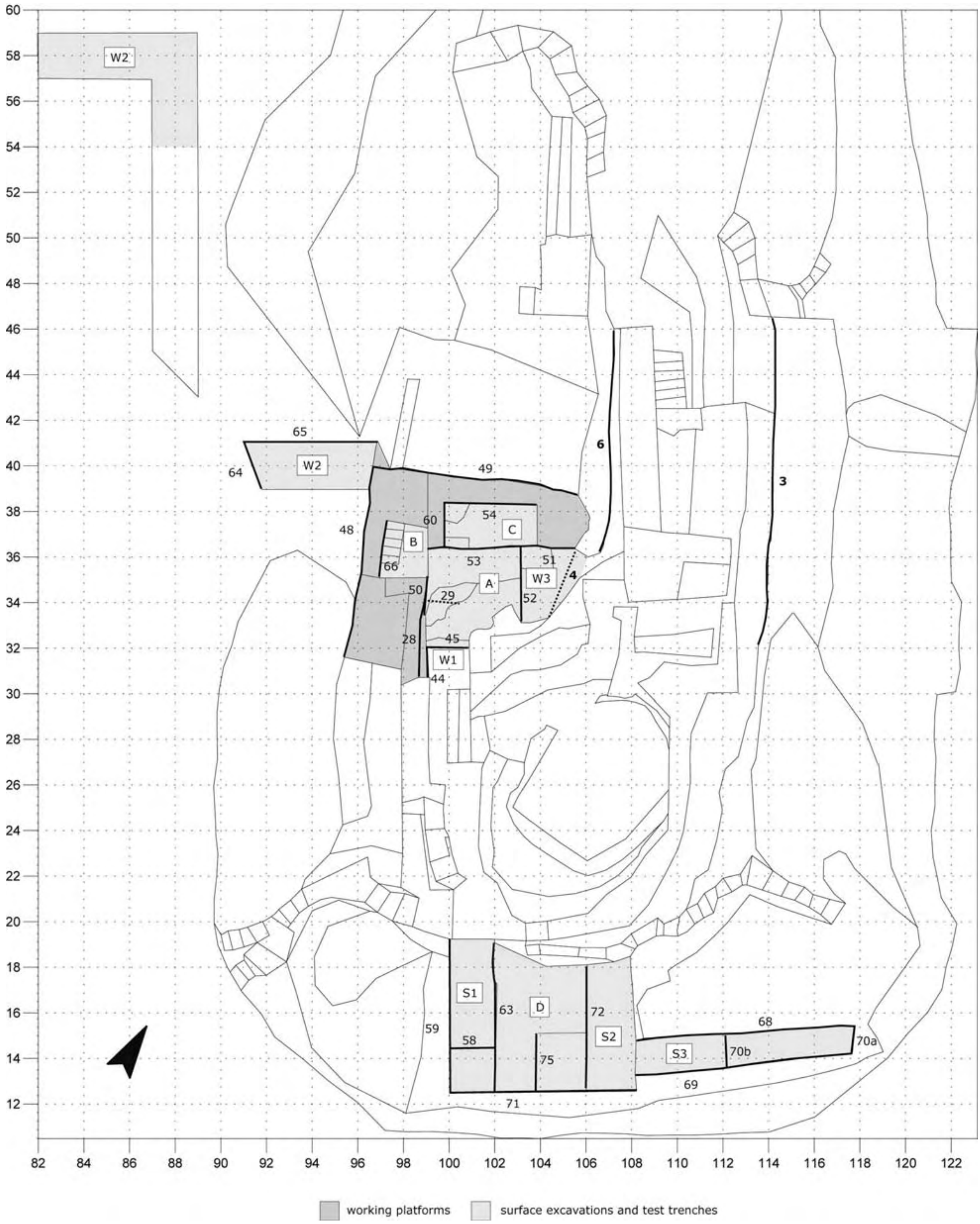


Fig.8: Location of excavation surfaces and test pits (2002-2009) covering the Mousterian deposits of Hummal. Profiles mentioned in text are indicated in bold figures and lines. Dotted lines indicate profiles which are no longer visible.

Fig.8

Fig.9: Excavation in the western and southern section of Hummal. The upper picture shows the excavation of Mousterian deposits in the western section in 2006. The excavation in the central part of Hummal is visible in the right half of the picture. The lower picture depicts the situation in the southern section of Hummal after the 2009 excavation.

Fig.9

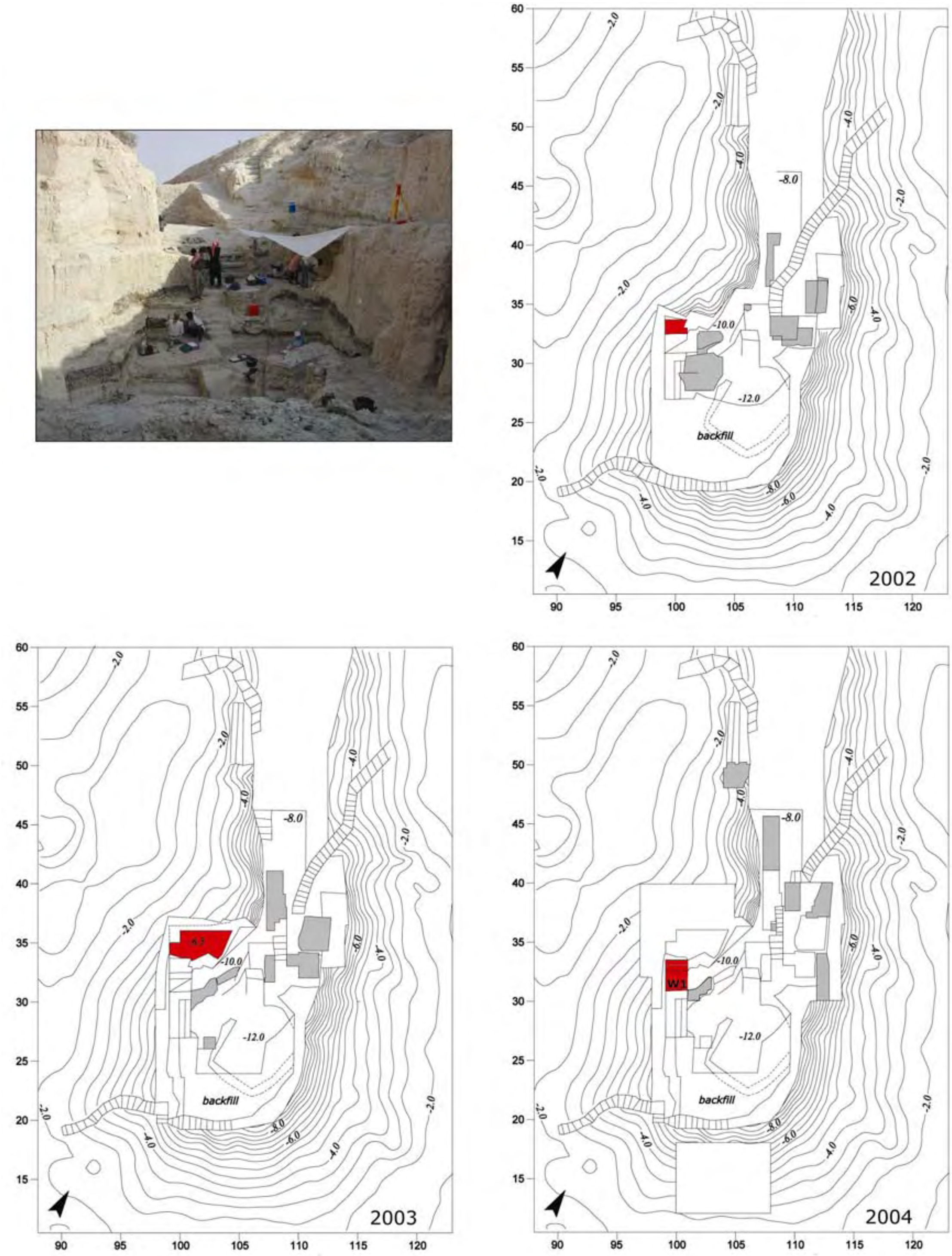


Fig.10: Extent of excavations in Hummal between 2001 and 2004. The picture in the upper left shows the excavation in the central part of the well in 2001. The unexcavated western Mousterian sequence is visible in the left part lit by the sunshine. The maps illustrate the location of excavated sections in 2002, 2003 and 2004. Excavations in Mousterian deposits are indicated in red, excavations in other archaeological complexes are indicated in grey.

Fig.10

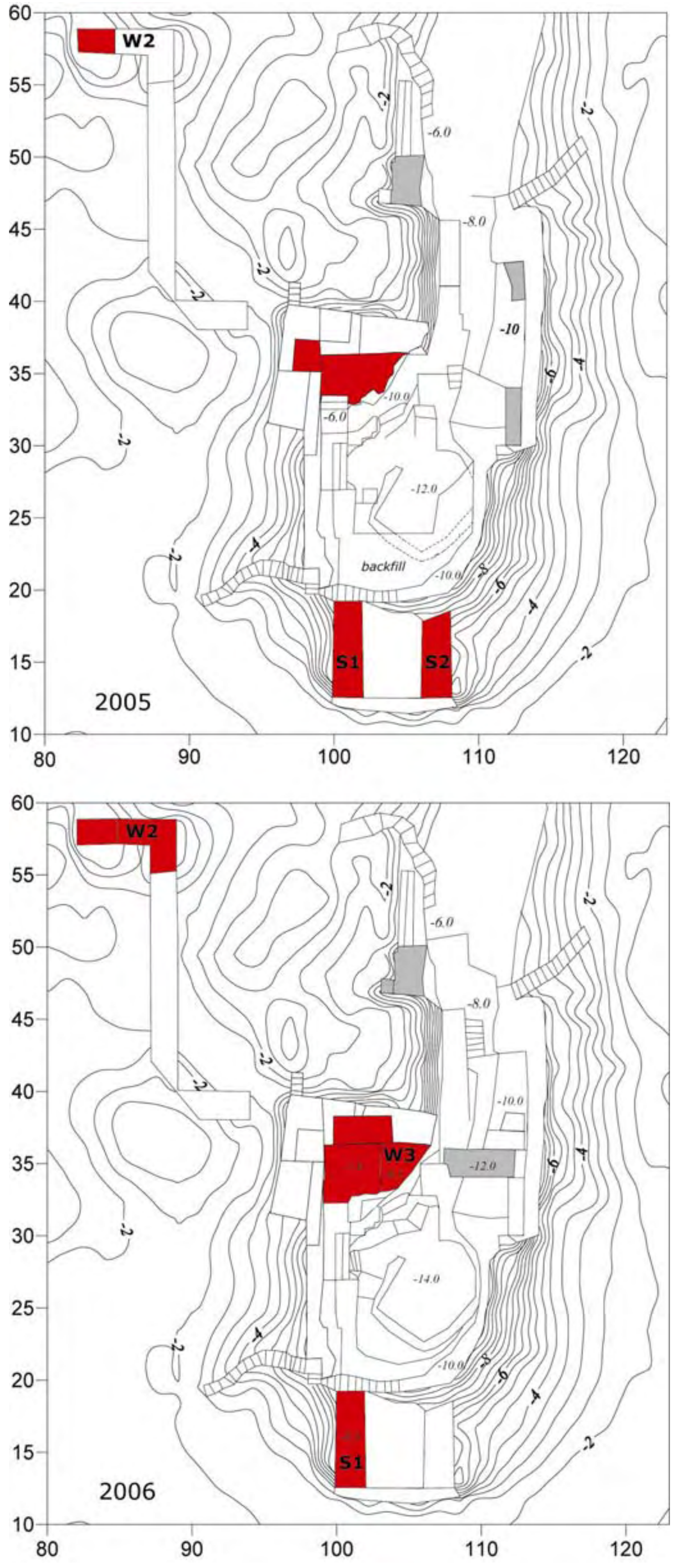


Fig.11: Location and extent of excavation areas in Hummal in 2005 and 2006. Excavations in Mousterian deposits are indicated in red, excavations in other archaeological complexes are indicated in grey.

Fig.11

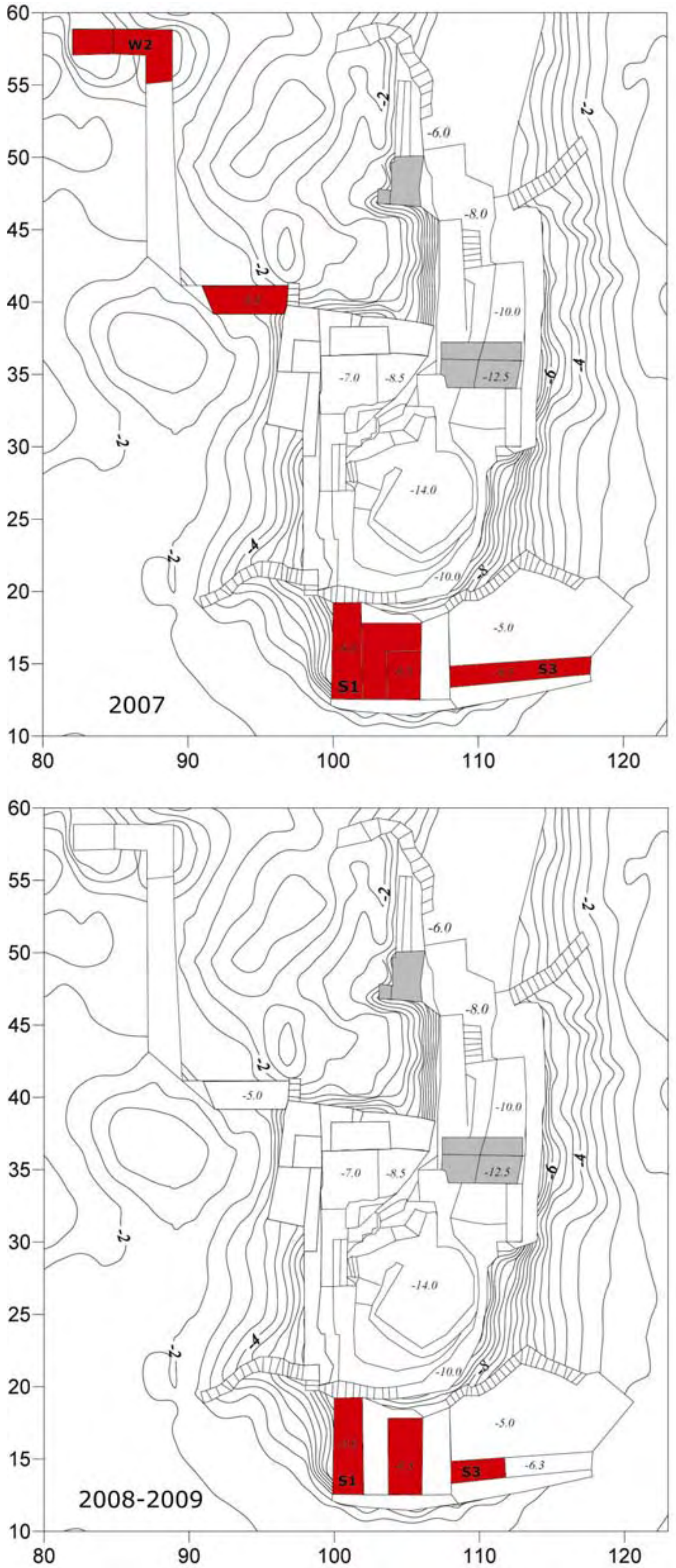


Fig.12: Location and extent of excavation areas in Hummal in 2007 and 2008. Excavations in Mousterian deposits are indicated in red, excavations in other archaeological complexes are indicated in grey.

Fig.12

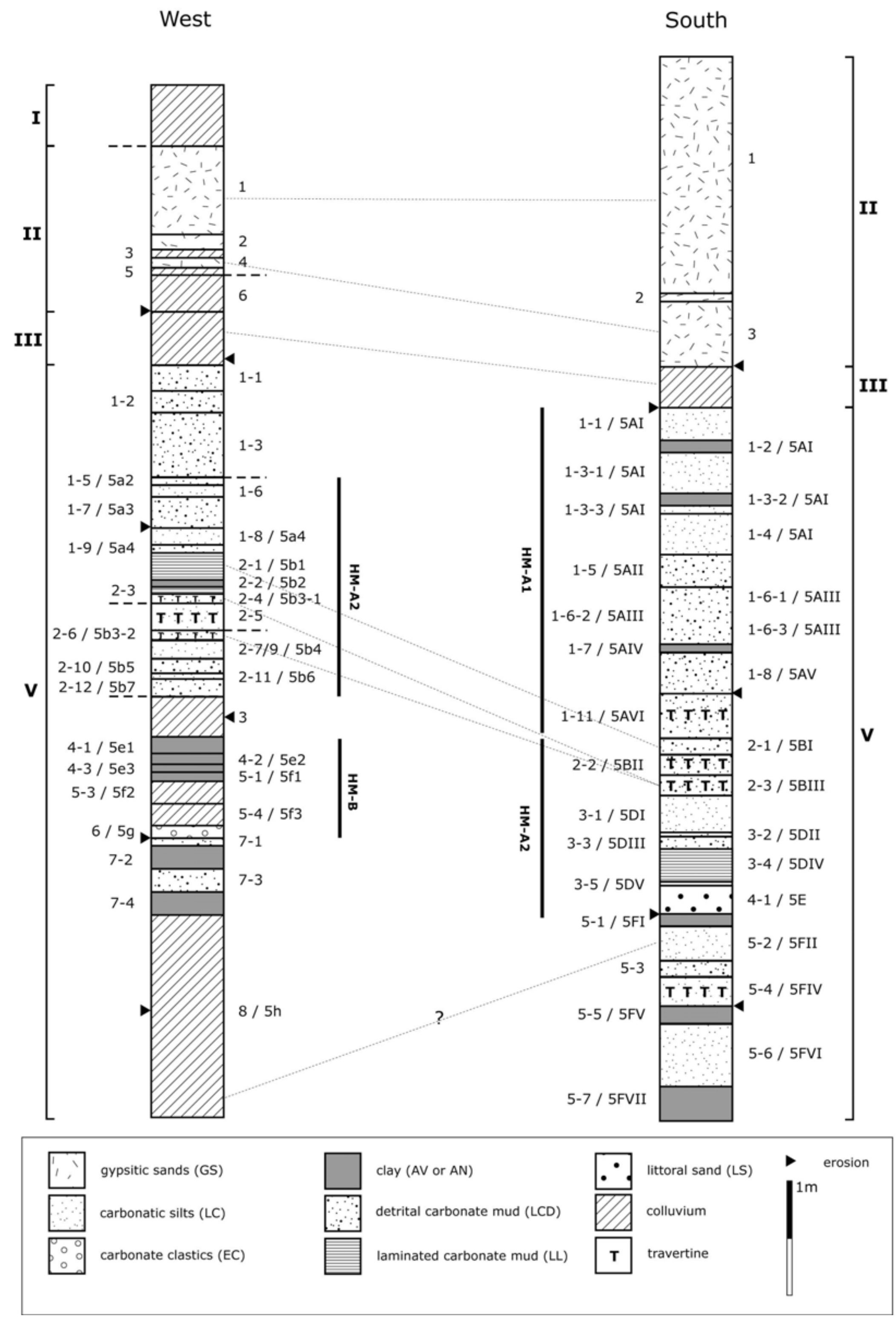


Fig.13: Synopsis of the depositional sequences in the western and southern section of Hummal. The compilation of individual profiles in the western section is marked by dashed lines. Dotted lines between the two sequences indicate possible correlations. Geological complexes are described with Roman figures.

Fig.13

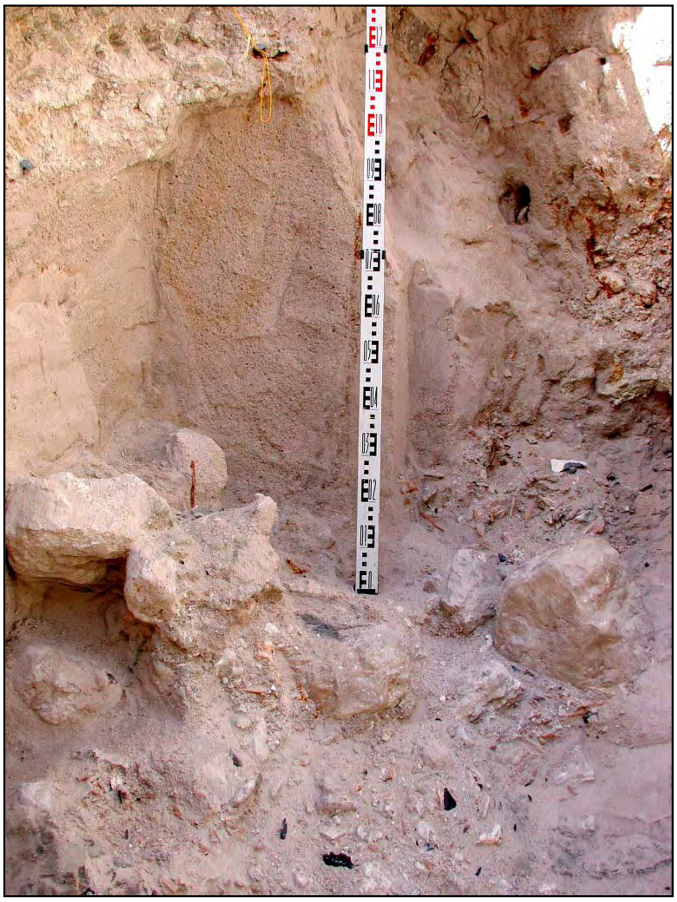


Fig.14: One of several massive quartz sand deposits found at the bottom of the well. This sand accumulation (alpha-m) contains thousands of well preserved lithic artifacts and faunal remains. It represents the remainder of a collapsed sediment package.

Fig.15: Microfaults and desiccation cracks at the transition between layer V1-9 (orange-green colored sediment in the upper part) and the freshwater carbonate of layer V2-1.

Fig.15

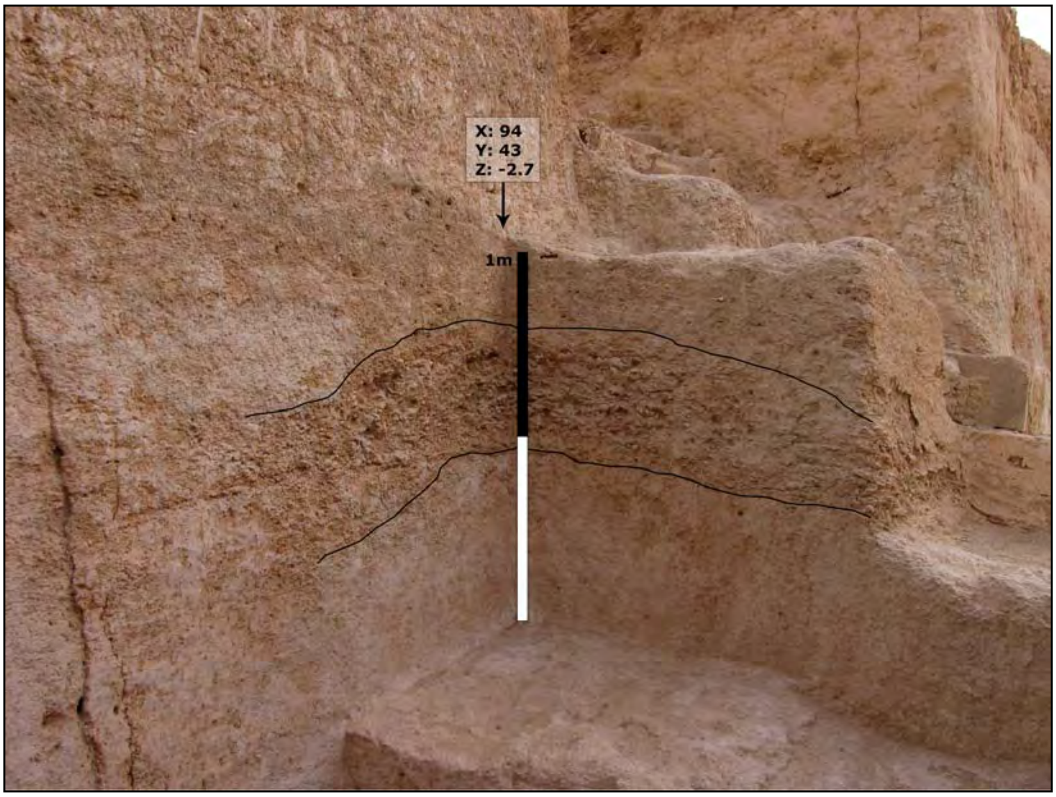


Fig.16: Scree consisting of travertine detritus forming a cone-shaped deposit in the uppermost part of the western sequence.

Fig.16

Fig.17: Laminated carbonate mud in level V2-1. The excavated upper part of archaeological level 5b3 is visible below. Red needles indicate the position of faunal remains.

Fig.17

Fig.18

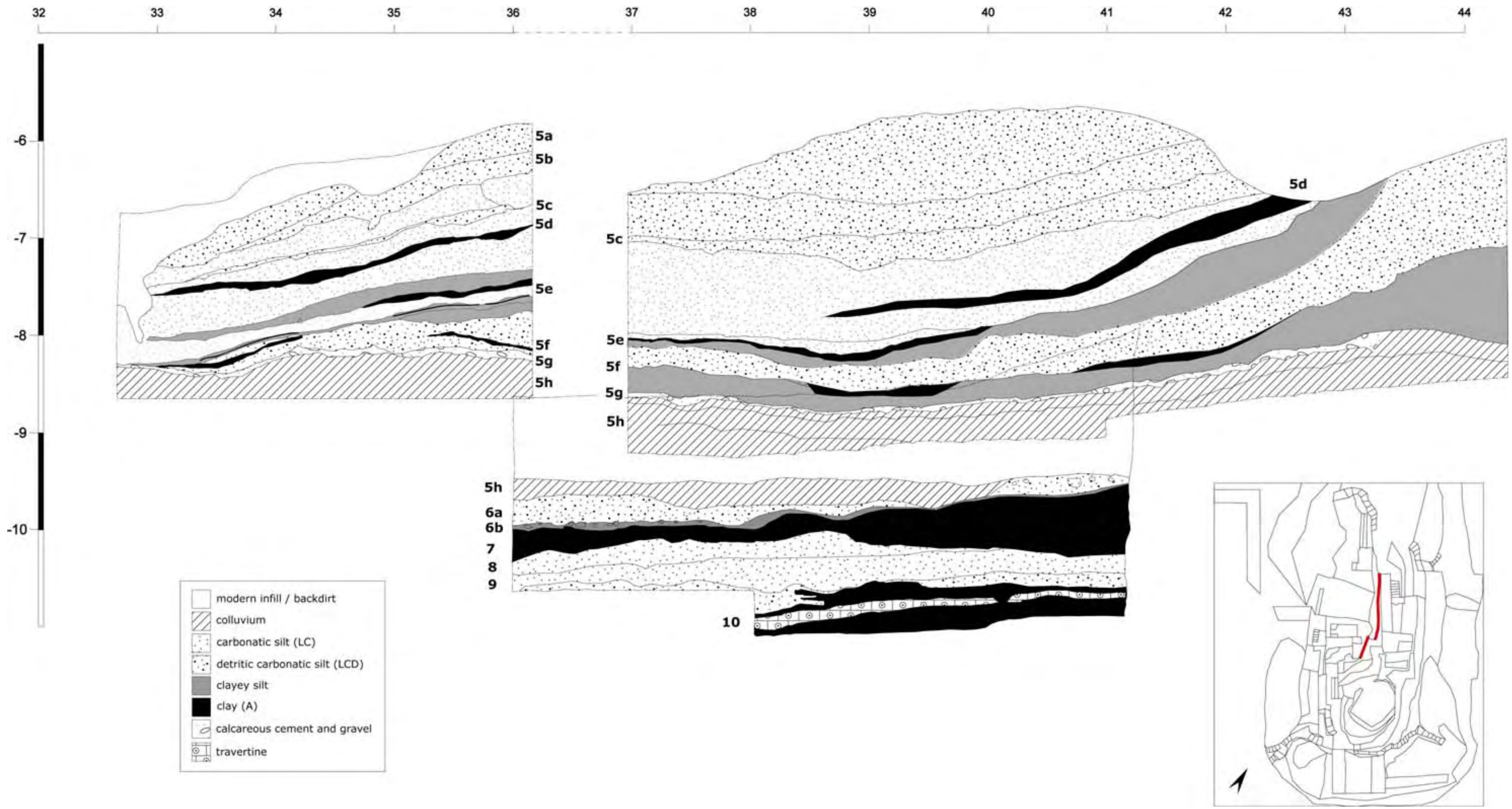


Fig.18: Profiles 4, 6 and 34 showing the Mousterian sequence (as defined in 1999) and underlying Hummalian (layer 6) and upper Yabroudian (layer 8-10) levels.

Fig.19

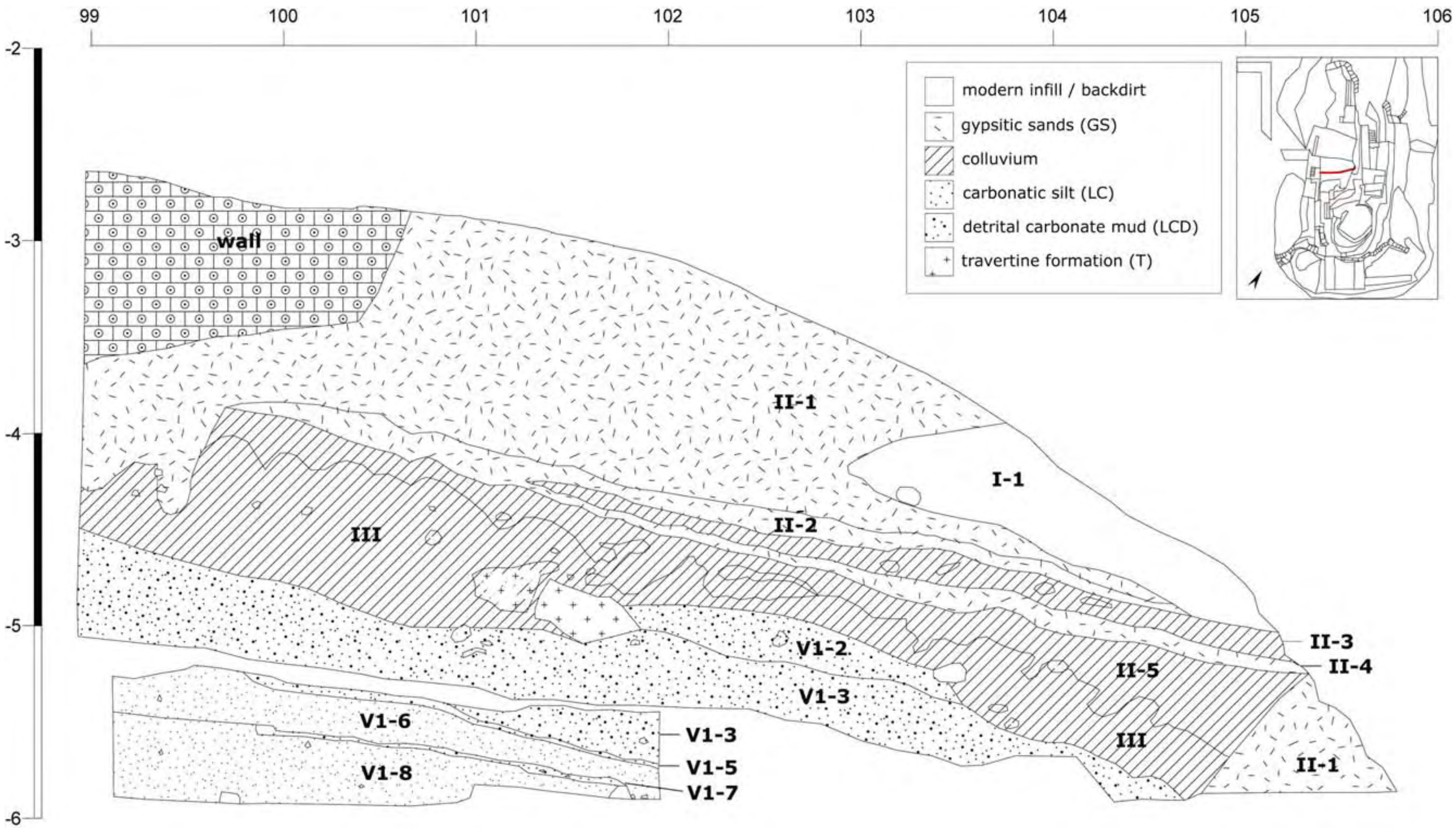


Fig.19: Profile 42 which documents the transition between modern backdirt (complex I), Holocene deposits (II, III) and the Pleistocene sequence (V) in the western section of Hummal.

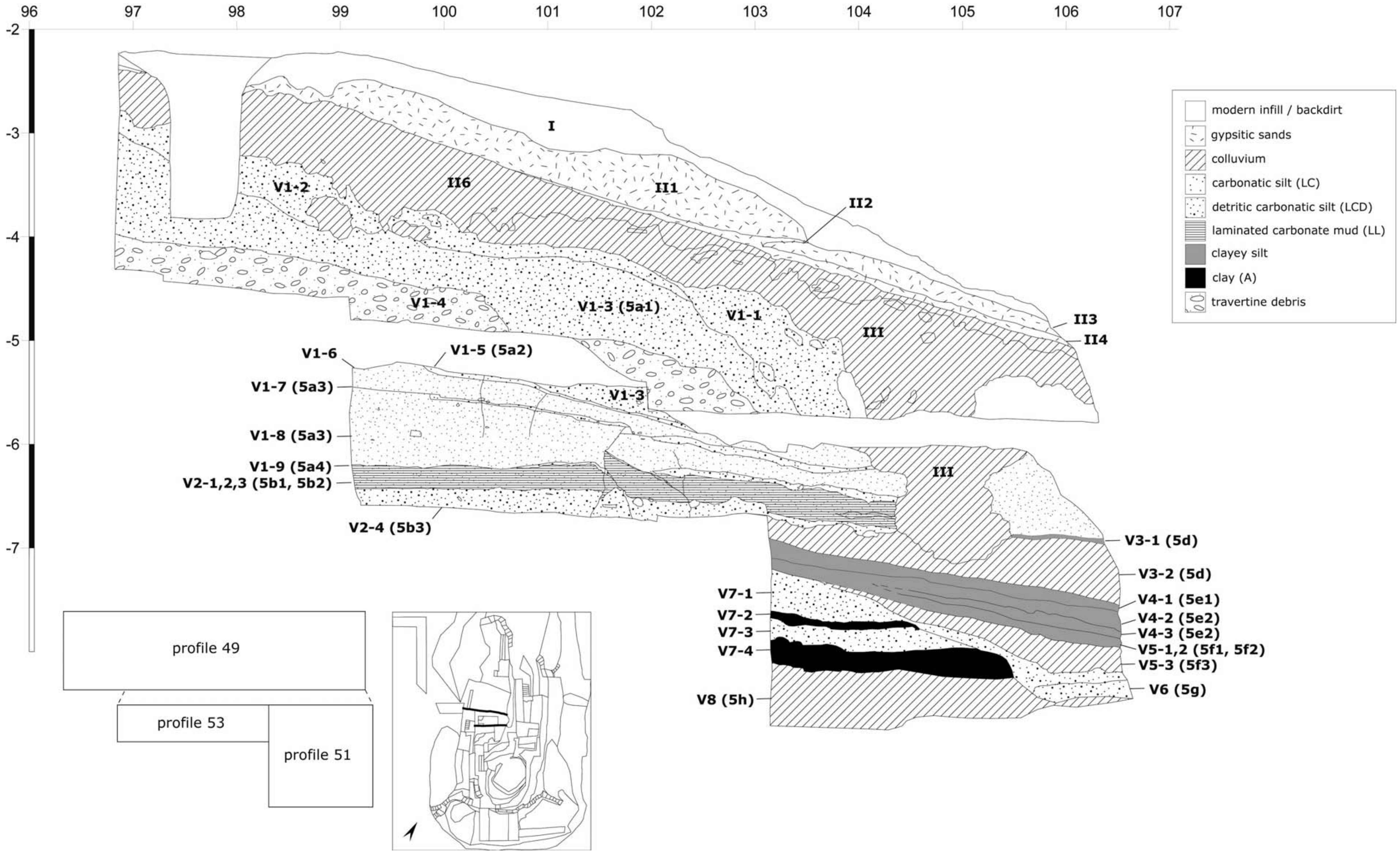


Fig.20: Compilation of profiles 49, 51 and 53 showing the Mousterian sequence in the western section of Hummal.

Fig.20

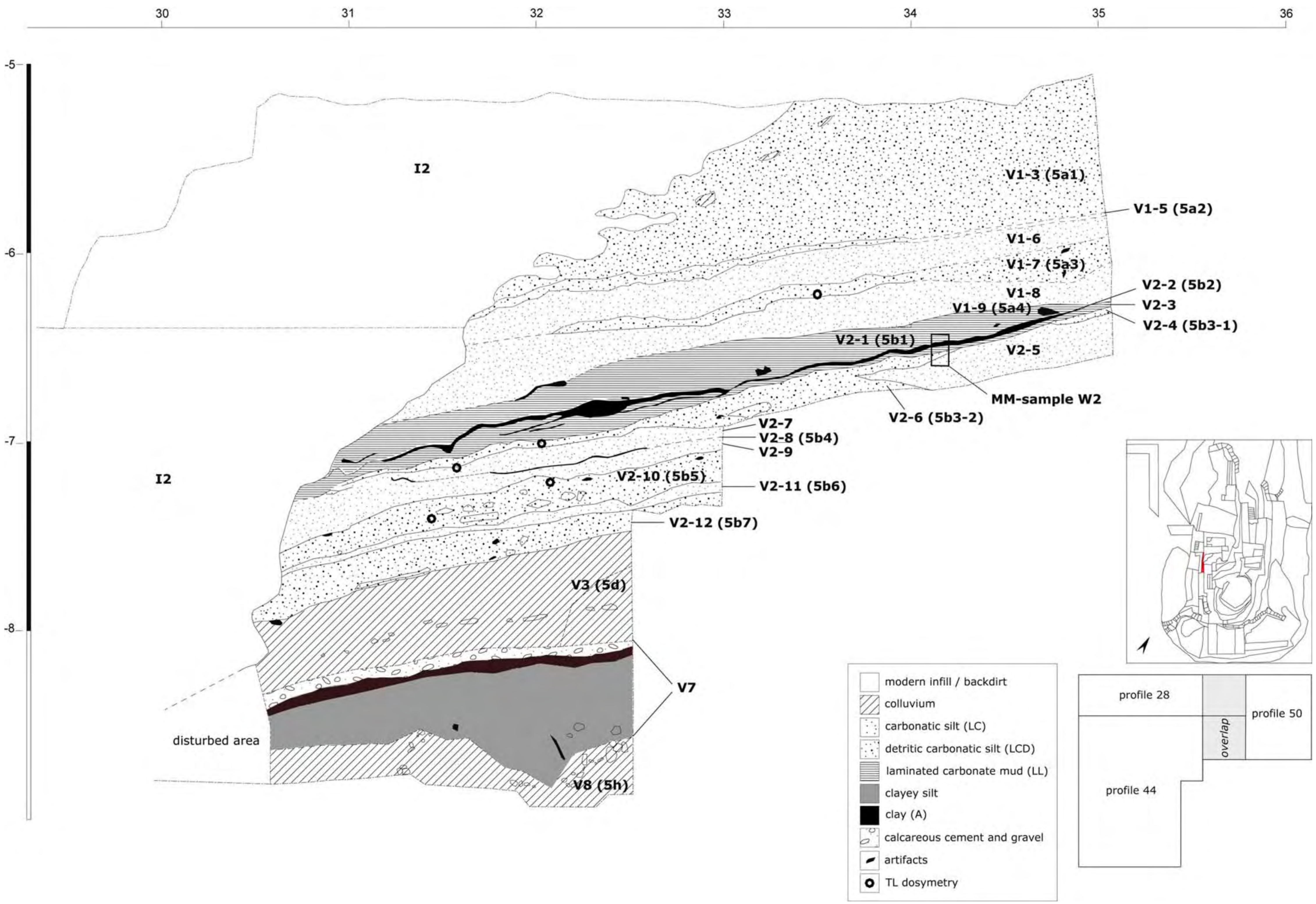


Fig.21: Compilation of profiles 28, 44 and 50 showing the Mousterian sequence in the western section of Hummal. Note the sharp contact with the modern well infill (complex I2).

Fig.21

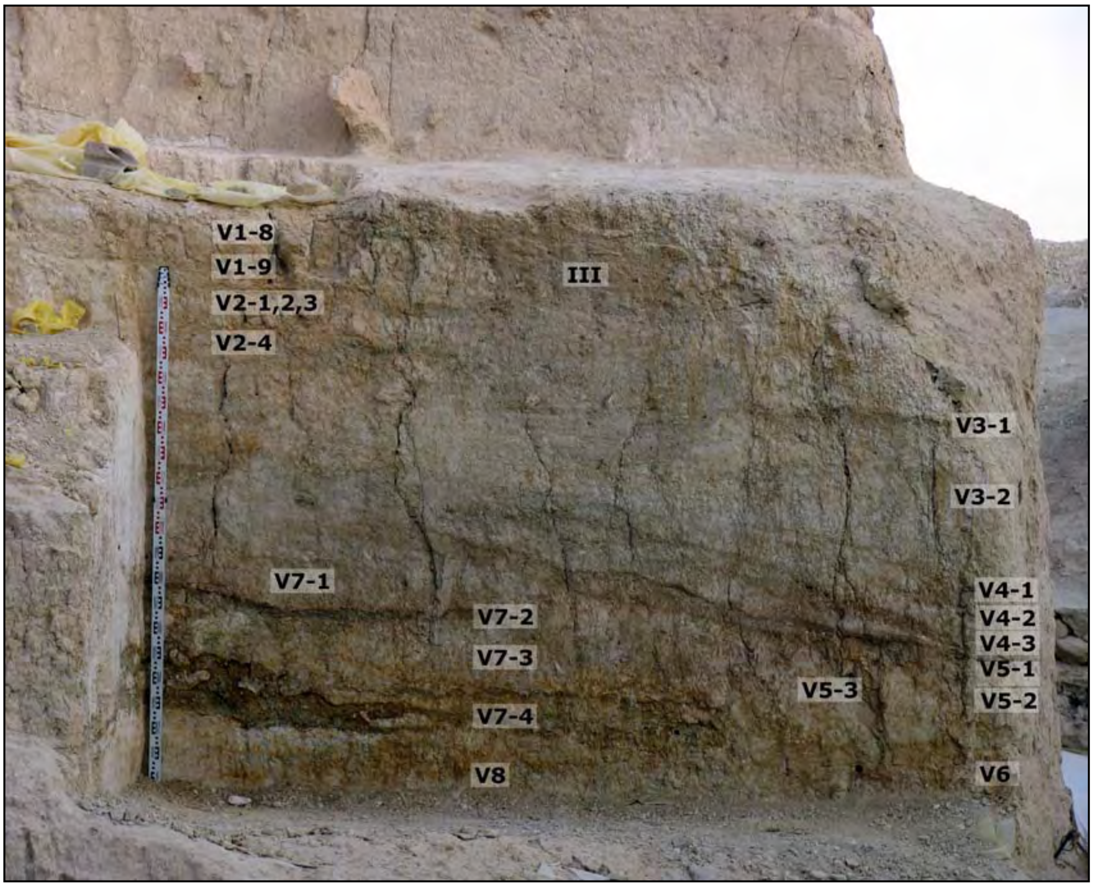


Fig.22: East-west running profile P51 in trench W3 showing the lower part of the western Mousterian sequence.

Fig.22

Fig.23: East-west running profile P45 in trench W1 showing the alteration of freshwater carbonates and detrital carbonate muds of complex V2 in its upper half and colluviated deposits V3 and V8 in its lower half.

Fig.23

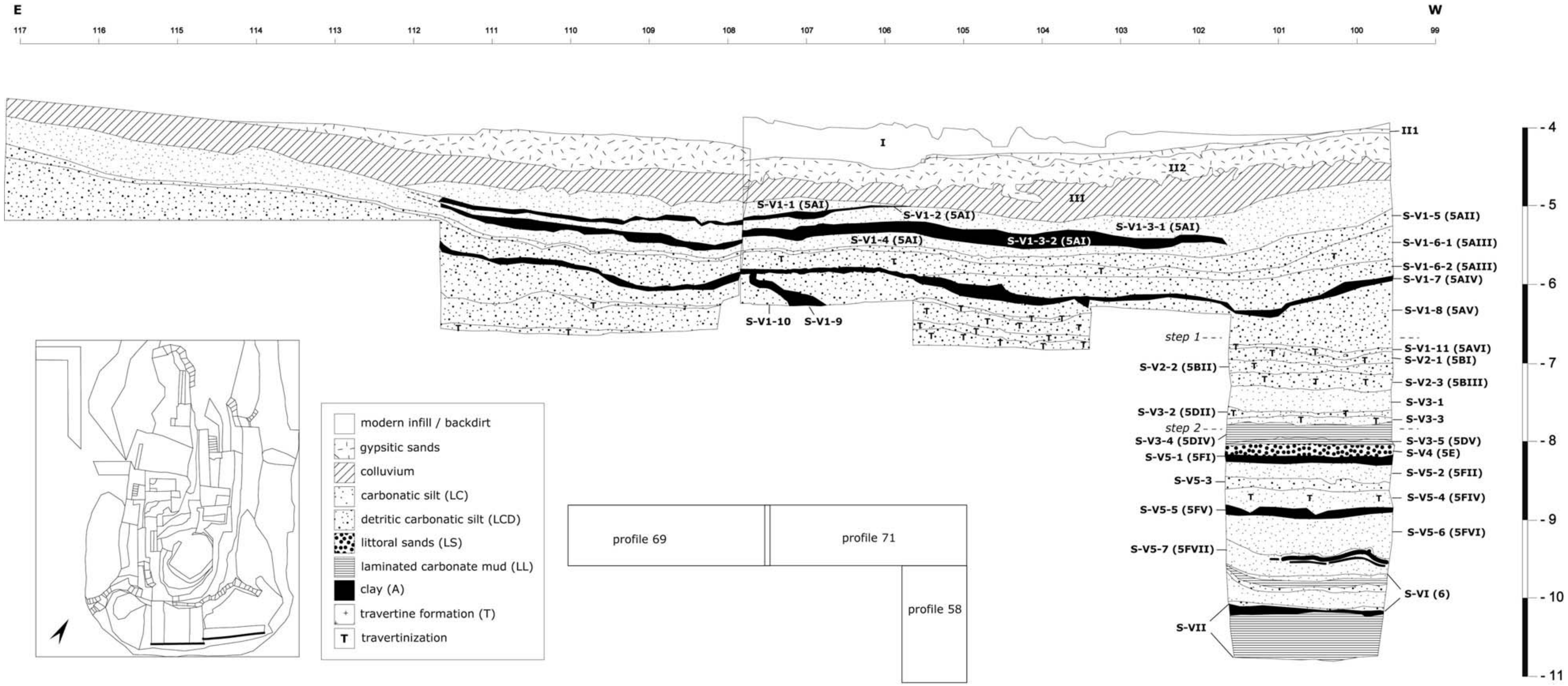


Fig.24: Compilation of profiles 58, 69 and 71 showing the complete southern Mousterian sequence of Hummal.

Fig.24

Fig.25

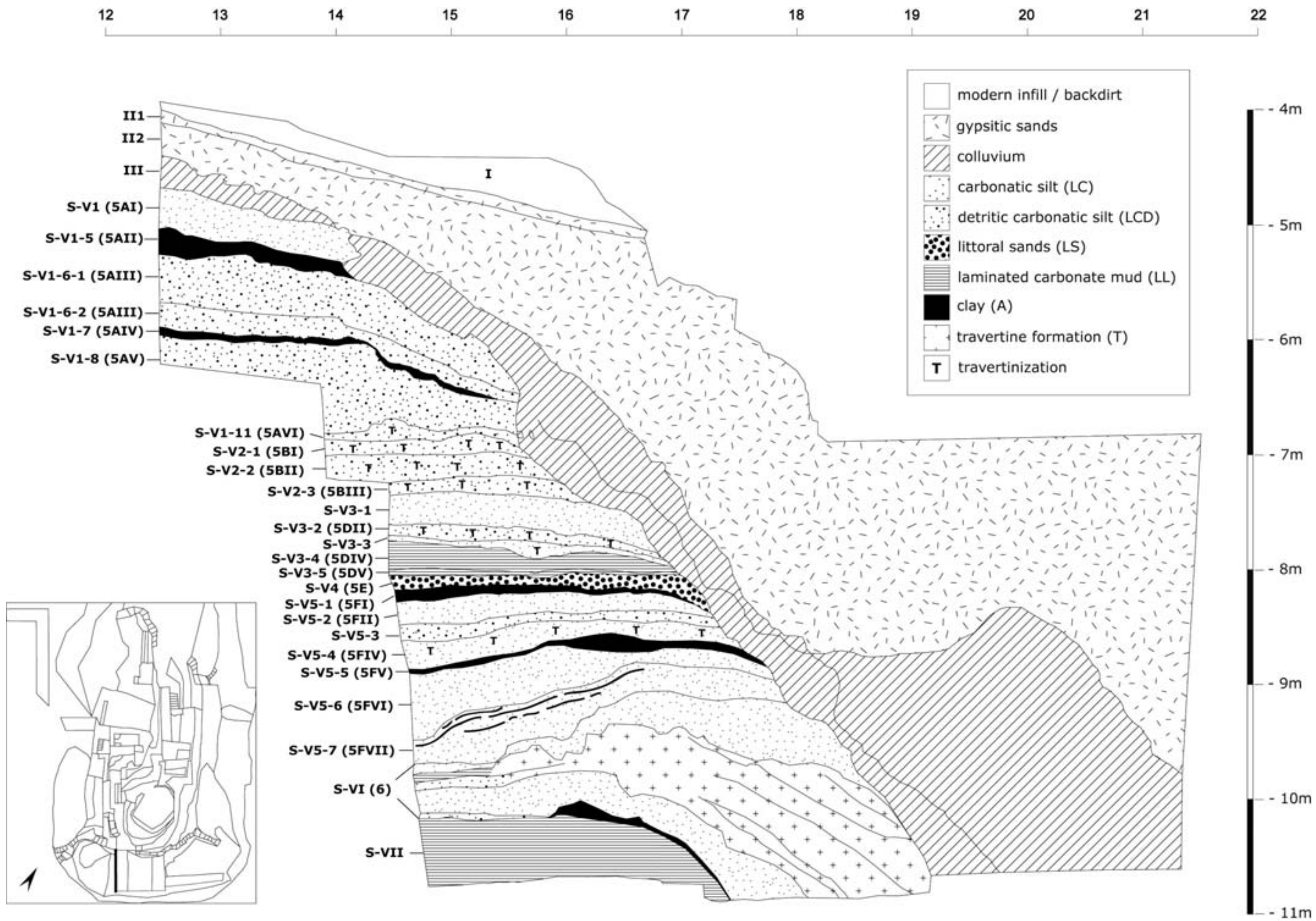


Fig.25: Profile 59 showing the southern Mousterian sequence and the contact between the in situ Pleistocene deposits, colluviated deposits and the modern well infill (complex II2).

Fig.26: East-west running profile P58 in trench S1 showing the lower part (complexes S-V4 and S-V5) of the southern Mousterian sequence.

Fig.26

Fig.27: Part of east-west running profile P71 showing Holocene complexes II and III at the top and the alternation between freshwater carbonates and palustrine deposits of complex S-V1 below. Visible at the base is the travertine formation of level 5BII.

Fig.27

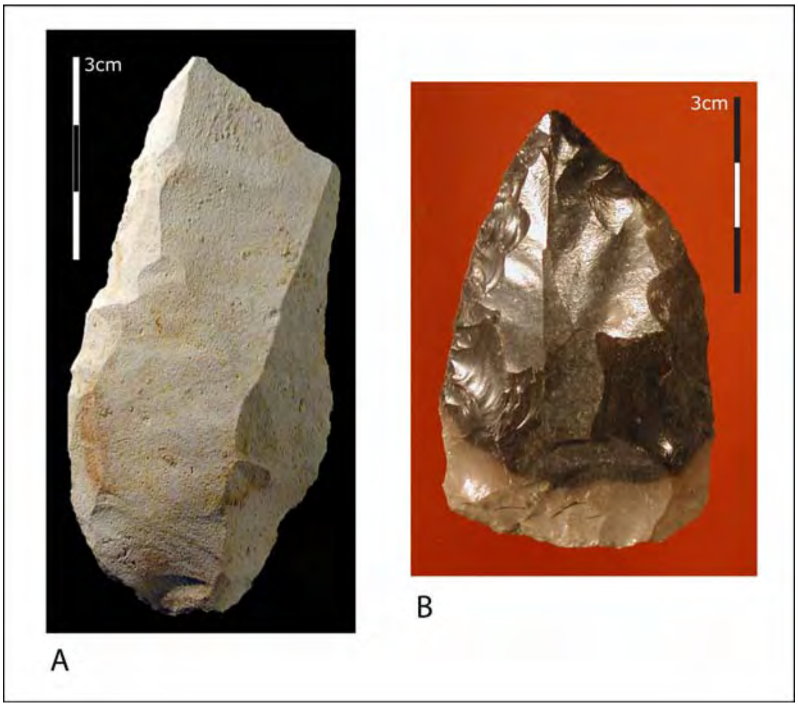


Fig.28: Examples of dissolution and accretion phenomena in the site of Hummal. Figure A: Levallois blade which is seriously affected by de-dolomitization; Figure B: convergent side scraper exhibiting a glossy patina which is generated by the accretion of secondary SiO_2.

Fig.28

Fig.29: Desiccation cracks in complex V2. The fissures are filled with red-brown sediment which consists of infiltrated surface material and insect metabolites.

Fig.29

Fig.30: Irrigation channel with concrete base cut through the upper part of the western Mousterian sequence.

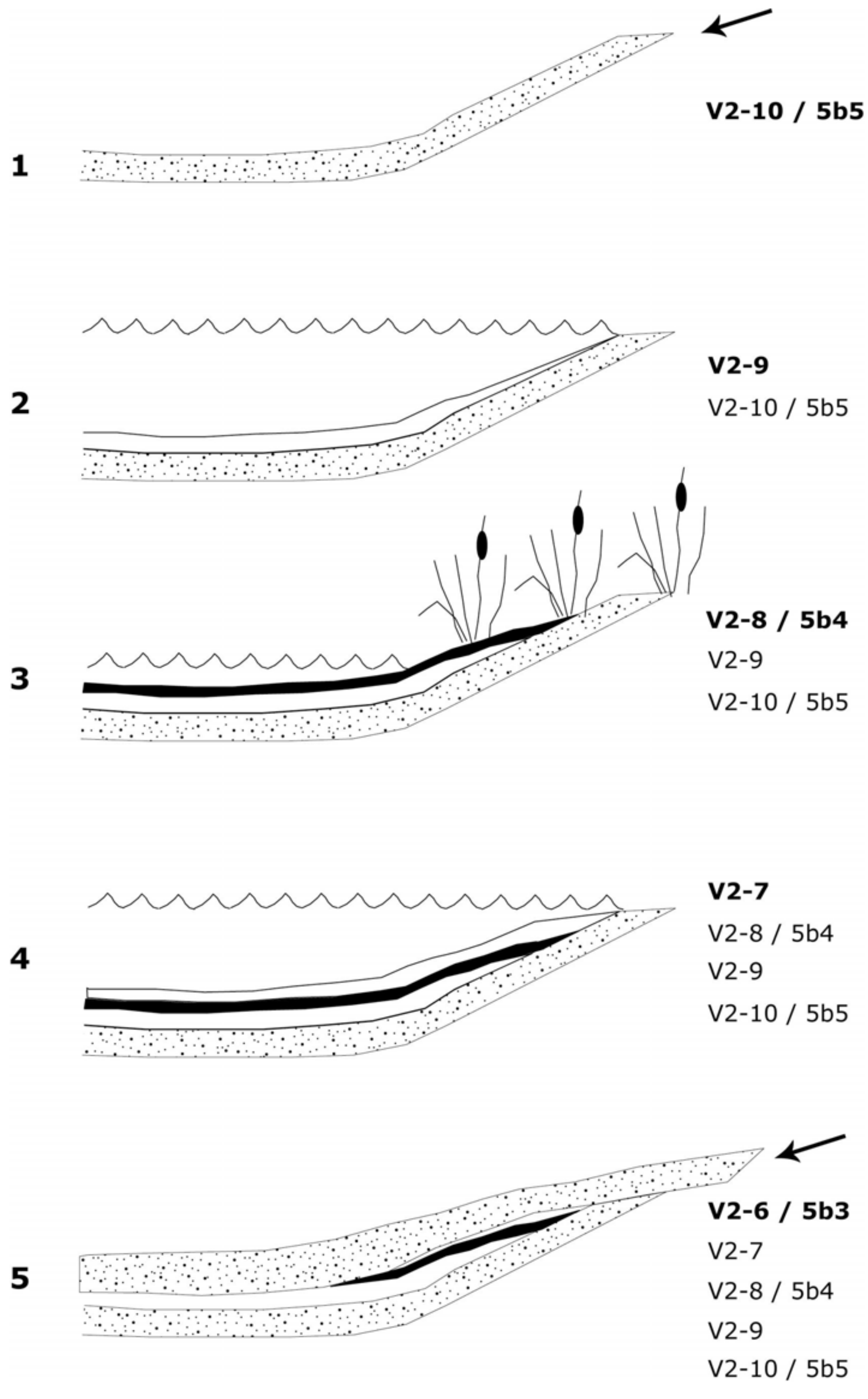


Fig.31: Model of deposition for layers V2-6 to V2-10 including archaeological levels 5b3, 5b4 and 5b5.

Fig.31

Fig.32: Section of level 5a3 (2005 excavation) showing a dense scatter of lithic artifacts and remains of camel embedded in a cemented detrital carbonate mud. Many larger artifacts are found with their ventral face upward. The transition between the Pleistocene deposit and the modern well infill is visible in the upper left

Fig.32

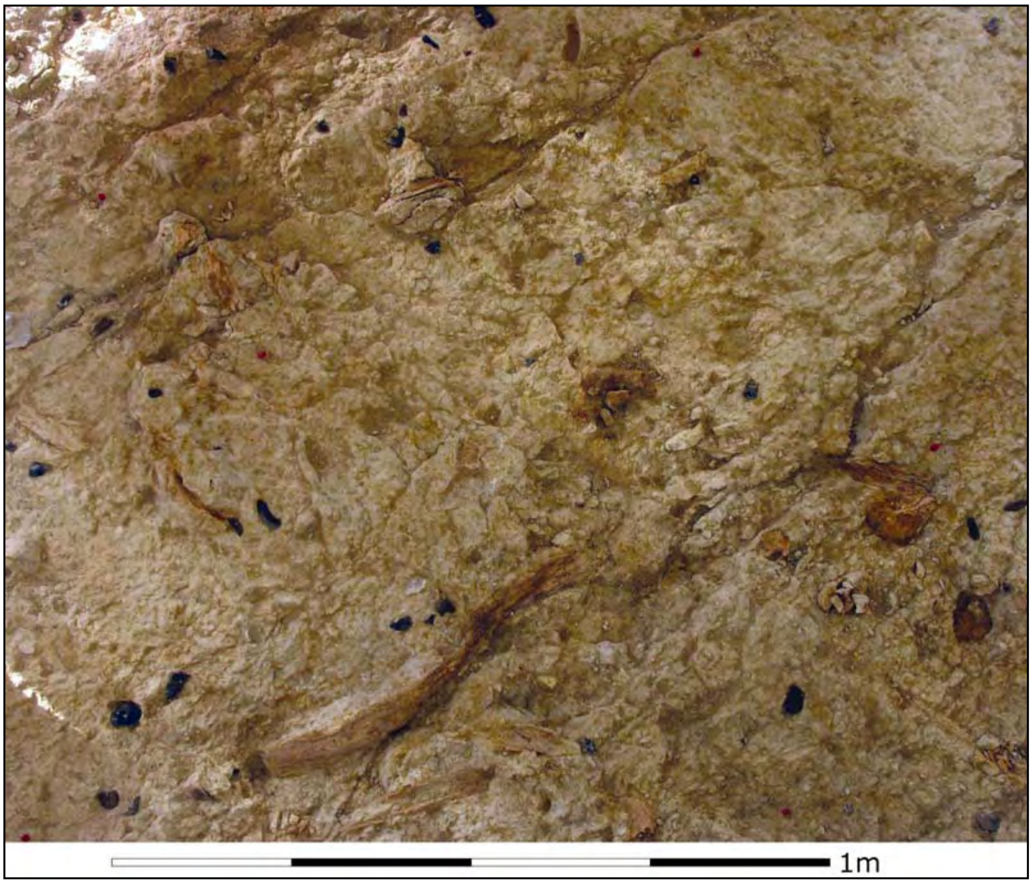


Fig.33: Section of level 5b3 (2006 excavation) showing a dense scatter of lithic artifacts and faunal remains embedded in a cemented detrital carbonate mud.

Fig.33

Fig.34

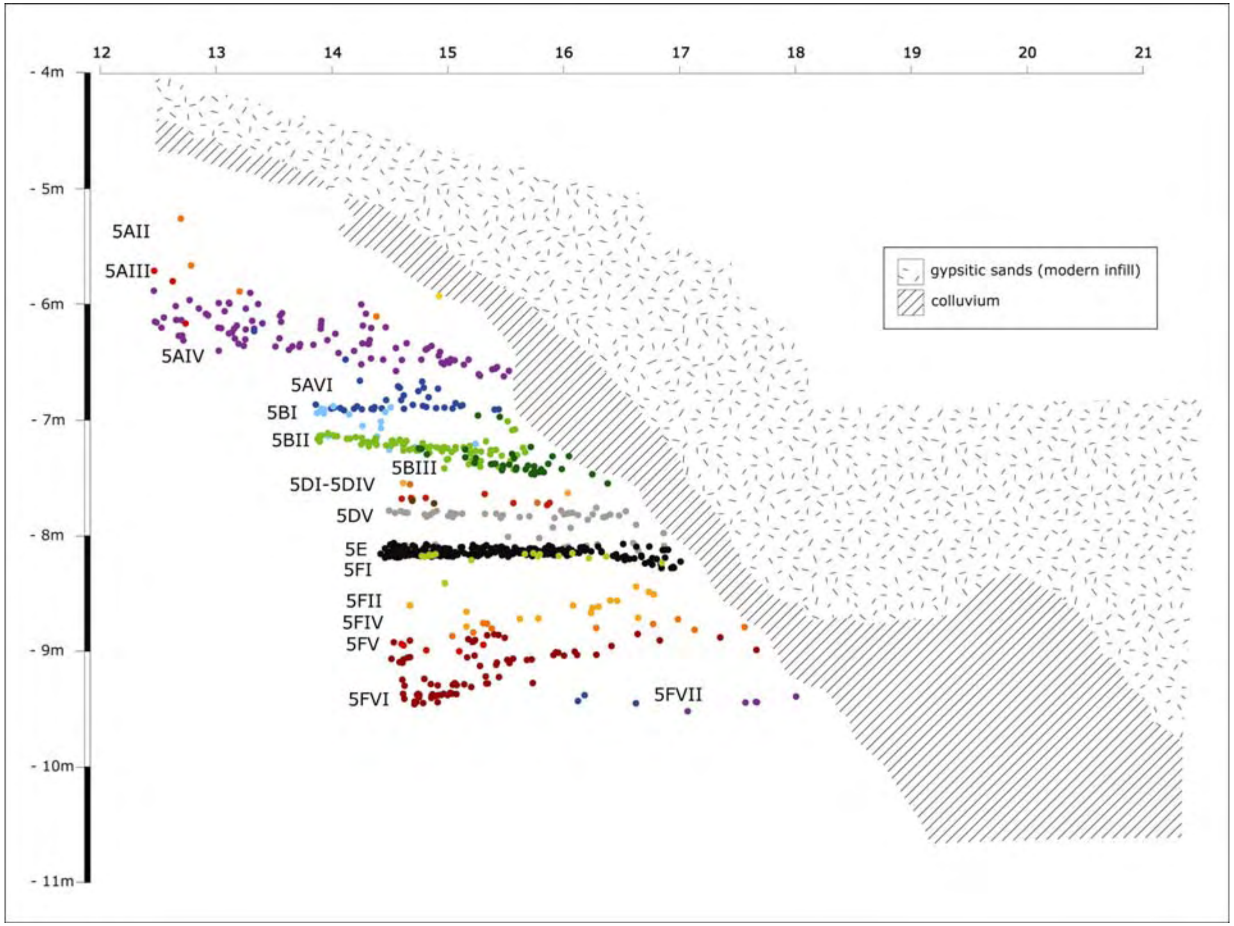


Fig.34: North-south running cross section through the southern Mousterian sequence with a plot of finds measured within the two meter wide strip of trench S1 (X=100-102). Note the variability of find density between levels and the truncation of archaeological deposits by colluviation processes and the modern well funnel.

Fig.35

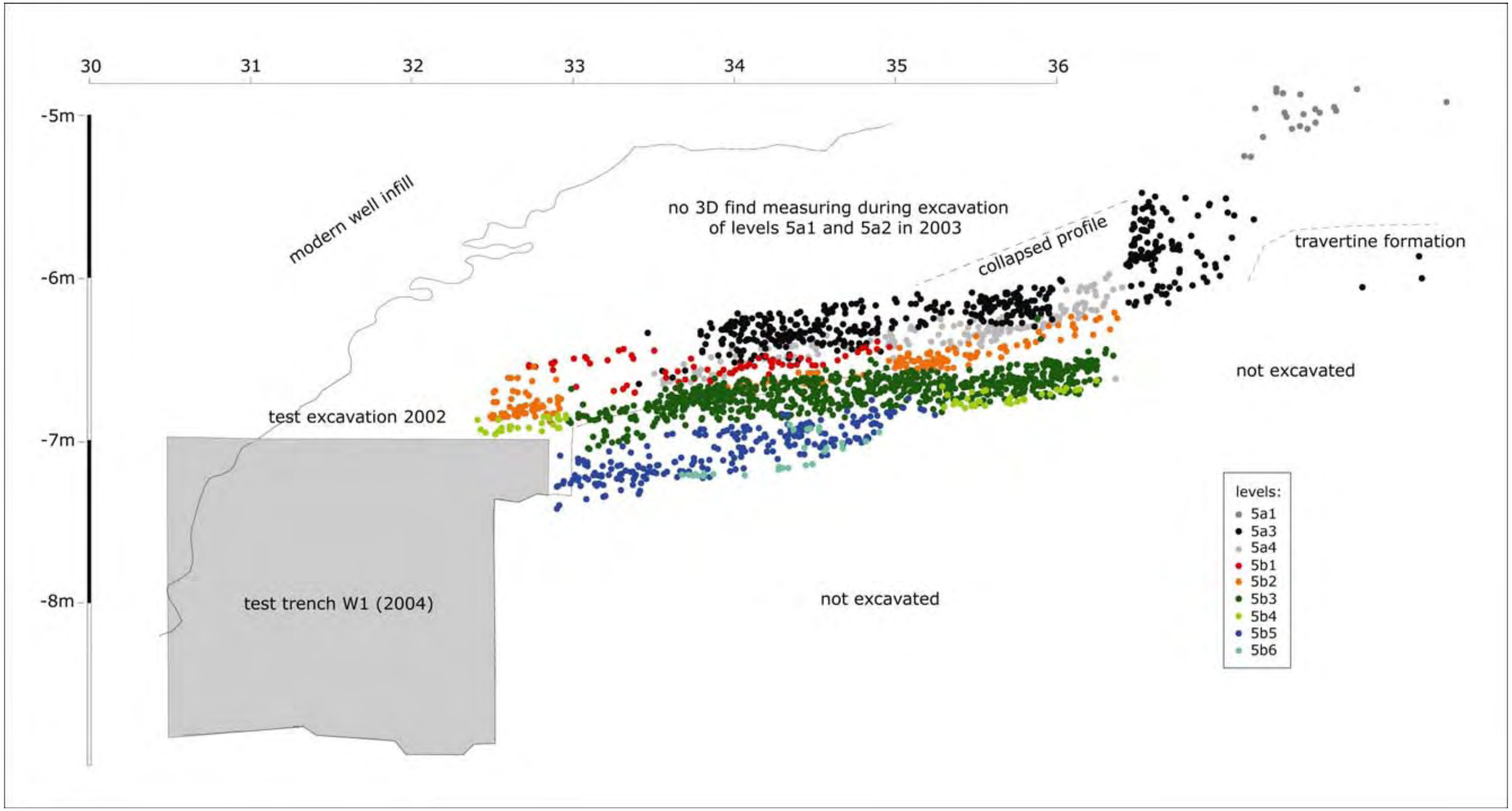
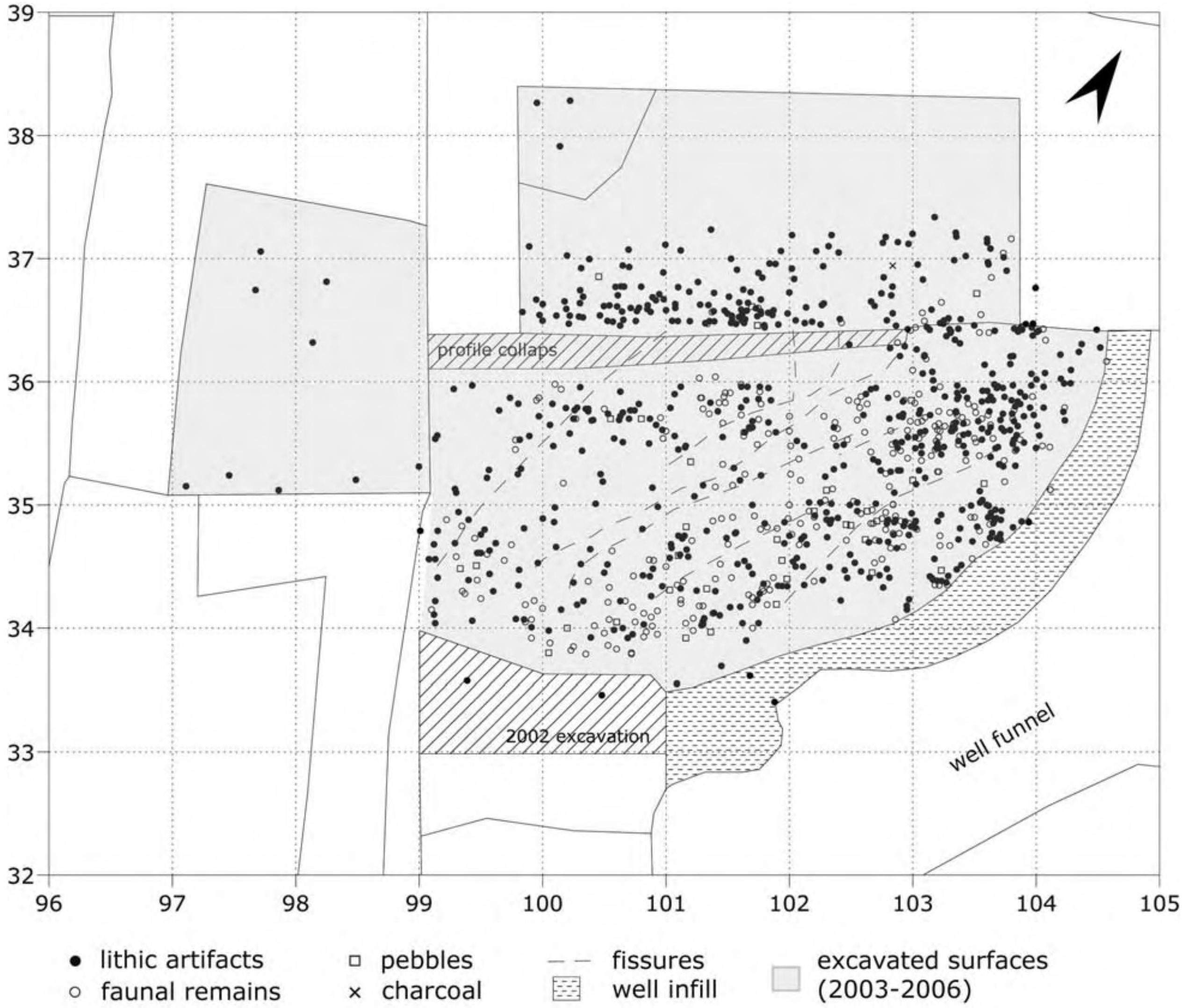


Fig.35: North-south running cross section through the upper part of the western Mousterian sequence with a plot of finds measured within a two meter wide strip at X=100-102. The plot shows only those finds which were recorded during the 2005-2006 excavations. The line marks the transition between the Pleistocene deposits and the modern well infill.

Fig.36: A typical field observation in littoral deposits is the embedding of are larger artifacts with their flat, ventral face upwards. The picture shows a Levallois point found at the base of level 5b5.

Fig.36



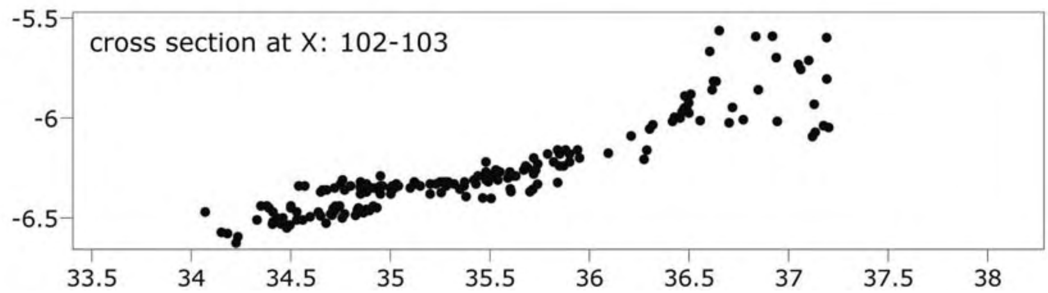


Fig.37: Horizontal distribution of archaeological remains in level 5a3 and the vertical distribution of finds in a 1m wide cross section at Y=102-103. Note the alignment of findings in between fissures and the decrease of find density in the western and northern direction.

Fig.37

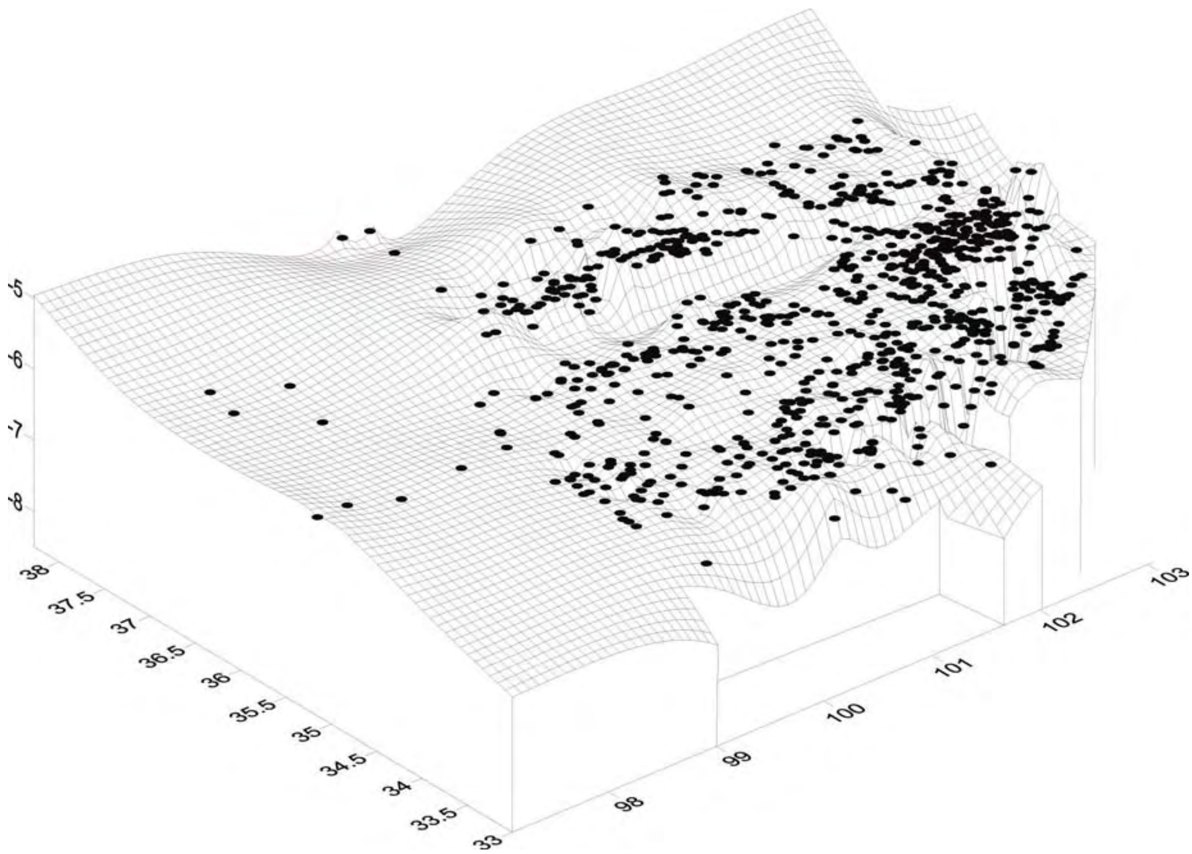


Fig. 38: Wireframe model showing the topography of excavated level 5a3. Note the clustering of objects in small depressions, which was probably caused by wave action and post-depositional shrinking effects due to desiccation.

Fig.38

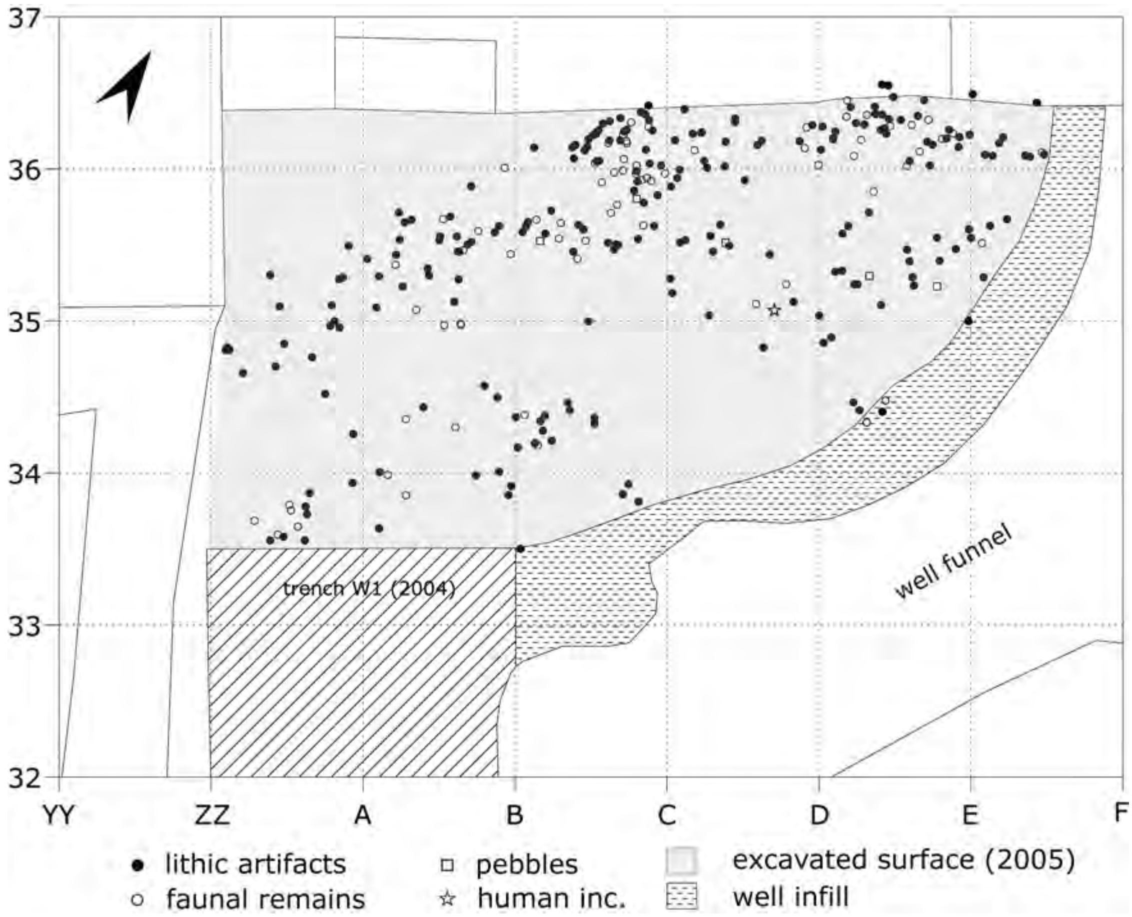


Fig.39: Horizontal distribution of archaeological remains in level 5a4.

Fig.39

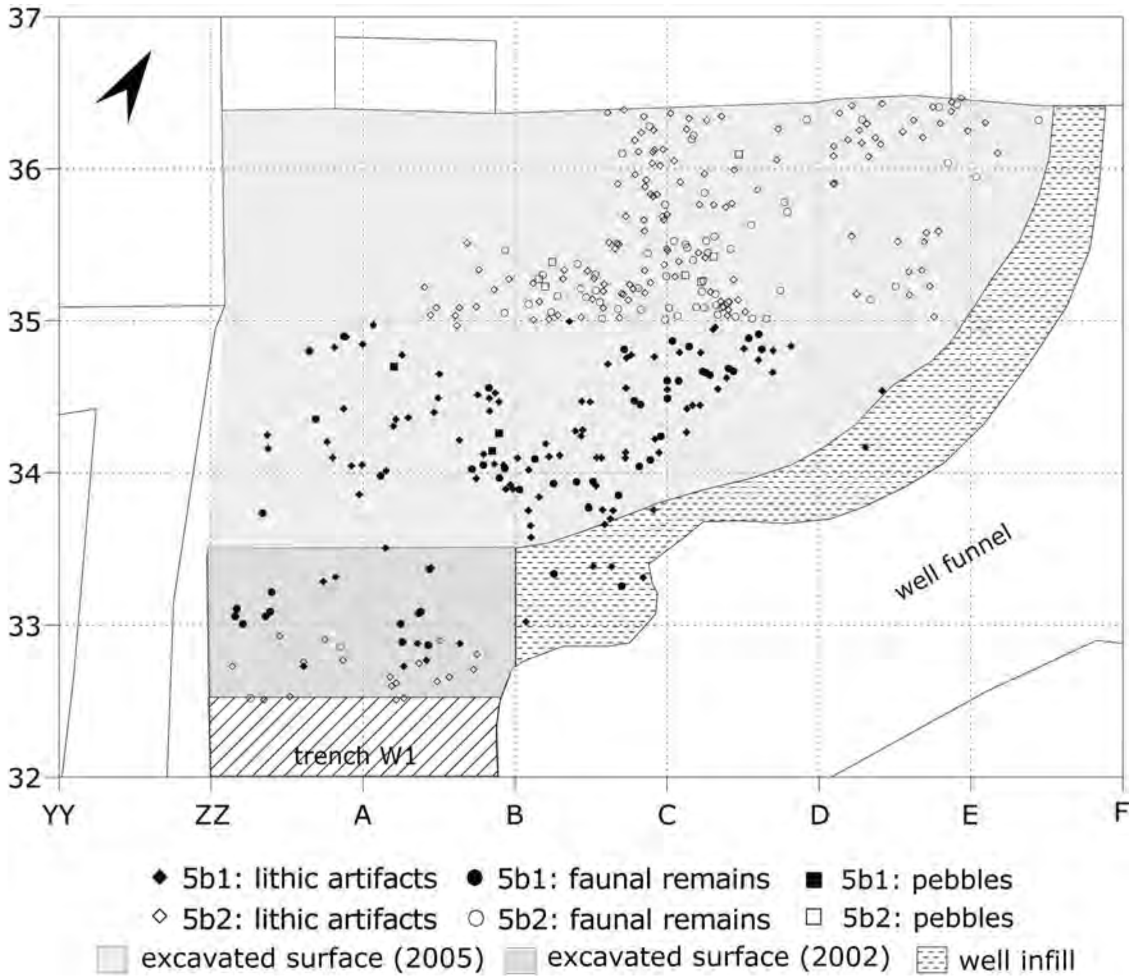


Fig.40: Horizontal distribution of archaeological remains in level 5b1 and 5b2.

Fig.40

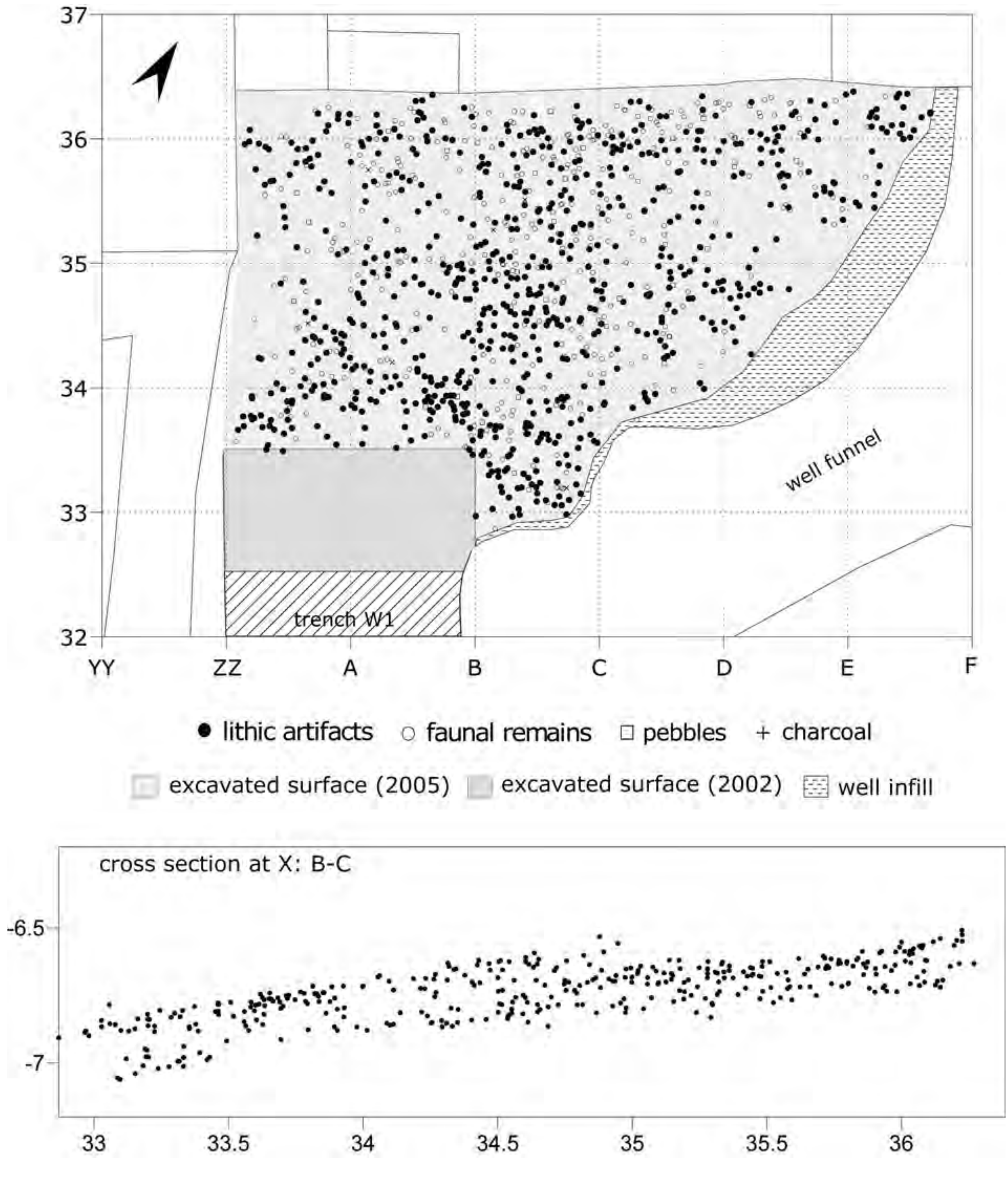


Fig.41: Horizontal and vertical distribution of archaeological remains in level 5b3. The separation of sub-level 5b3-1 and 5b3-2 is clearly visible in the cross section from Y:33 to Y:35.

Fig.41

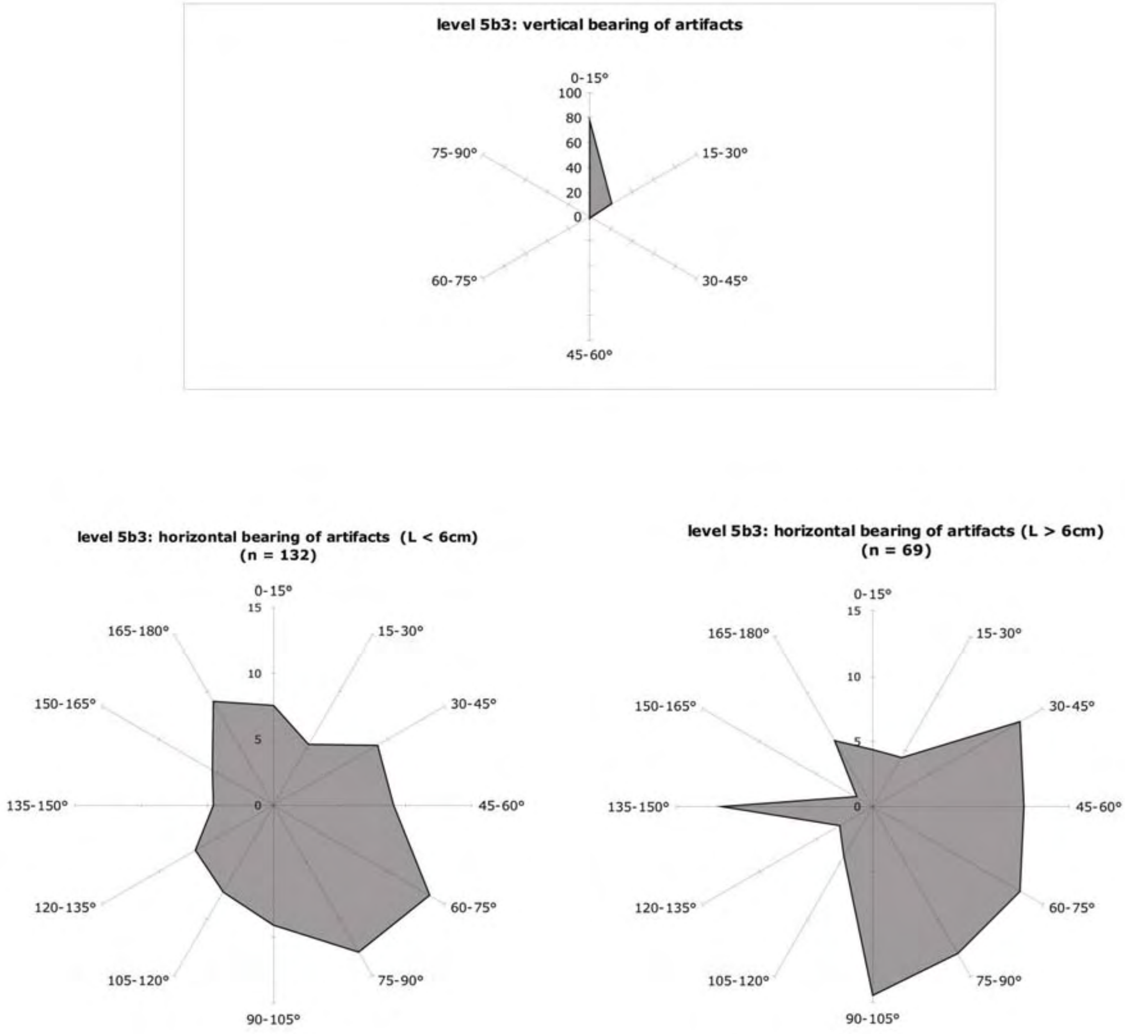


Fig.42: Vertical and horizontal bearing of lithic artifacts and bones larger than 2cm in level 5b3. The horizontal bearing is separately examined for objects smaller than 6cm and objects larger than 6cm.

Fig.42

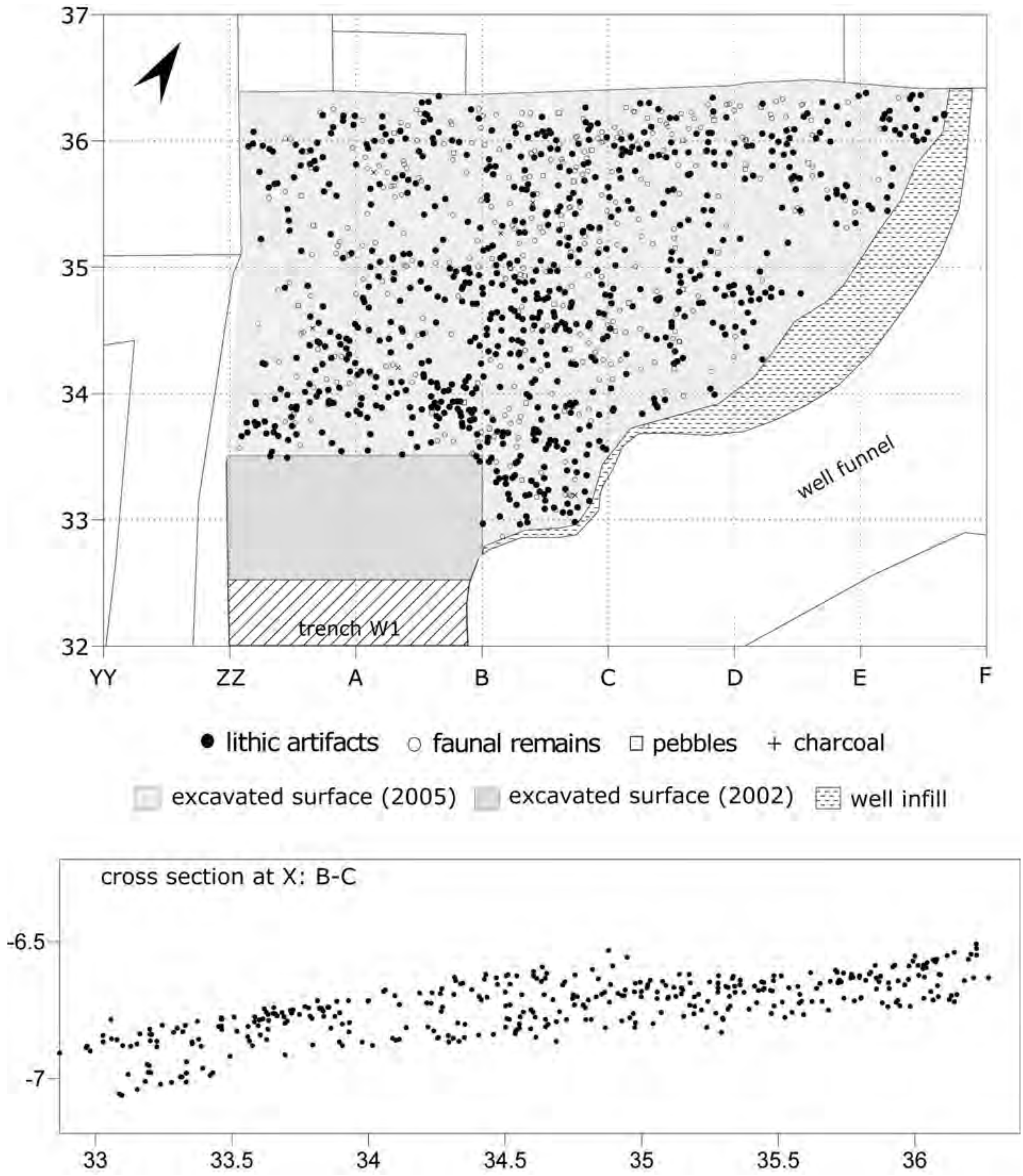
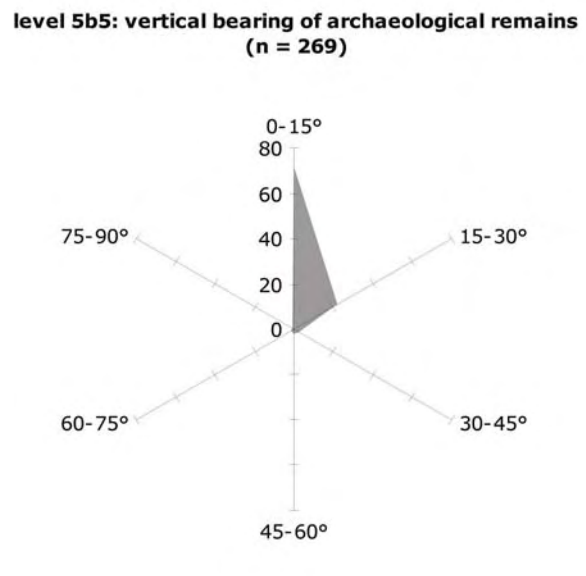


Fig. 43: Horizontal and vertical distribution of archaeological remains in level 5b3. The separation of sub-level 5b3-1 and 5b3-2 is clearly visible in the cross section from Y:33 to Y:35.

Fig.43



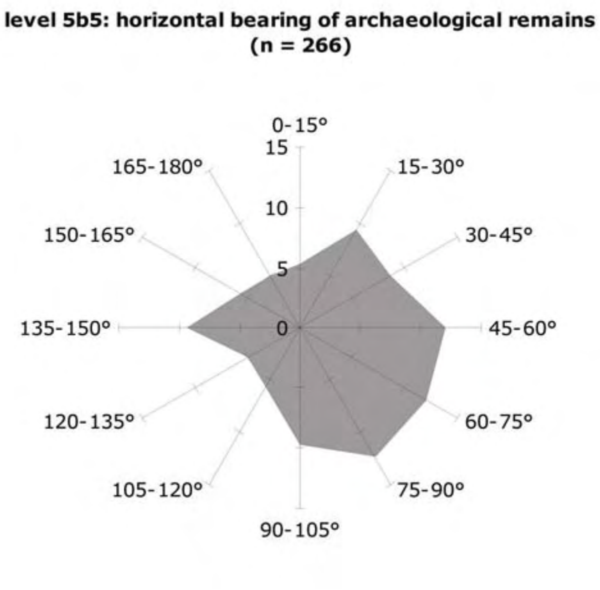


Fig.44: Vertical and horizontal bearing of archaeological remains larger than 2cm in level 5b5.

Fig.44

Fig.45

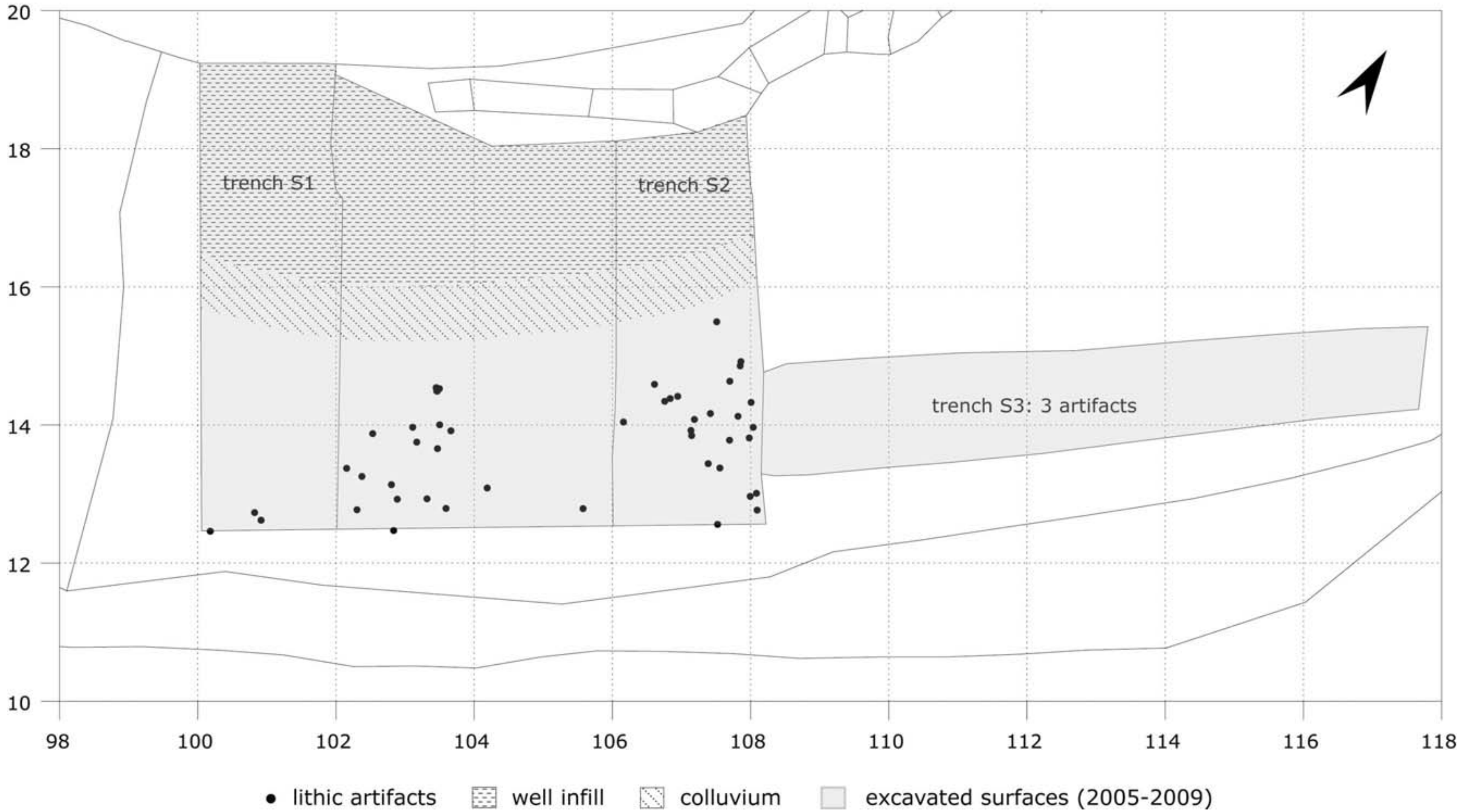


Fig.45: Horizontal distribution of archaeological remains in level 5AIII. Note the voids in trench S1 and on the surface between X=104-106.5.

Fig.46

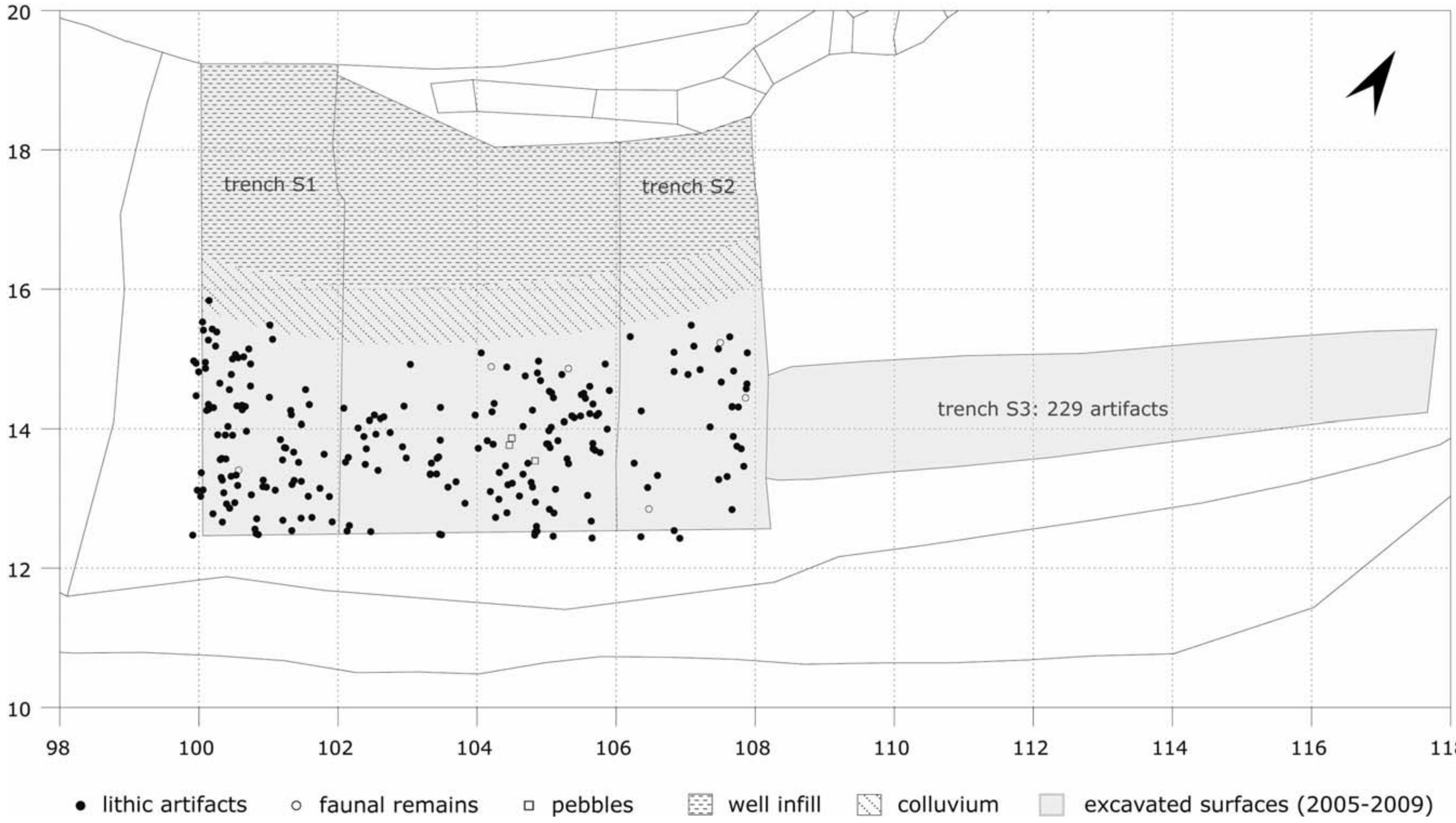


Fig.46: Horizontal distribution of archaeological remains in level 5AIV. Note that in trench S3 artifacts were not recorded in three dimensions.

Fig.47

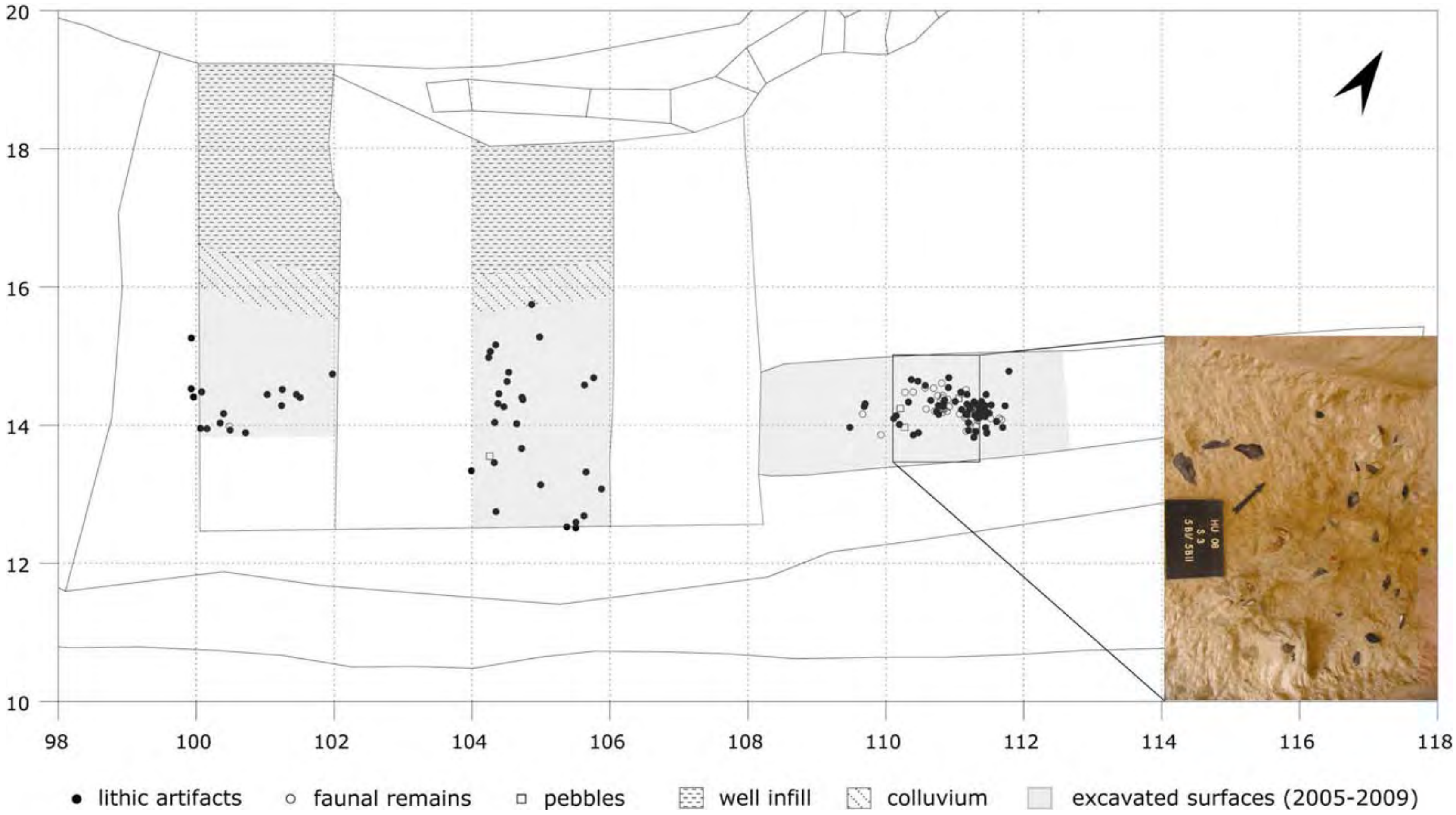


Fig.47: Horizontal distribution of archaeological remains in level 5BI. A remarkable find density was located in squares X:110-112/Y:13-14 in trench S3; the photo shows a section of this cluster.

Fig.48

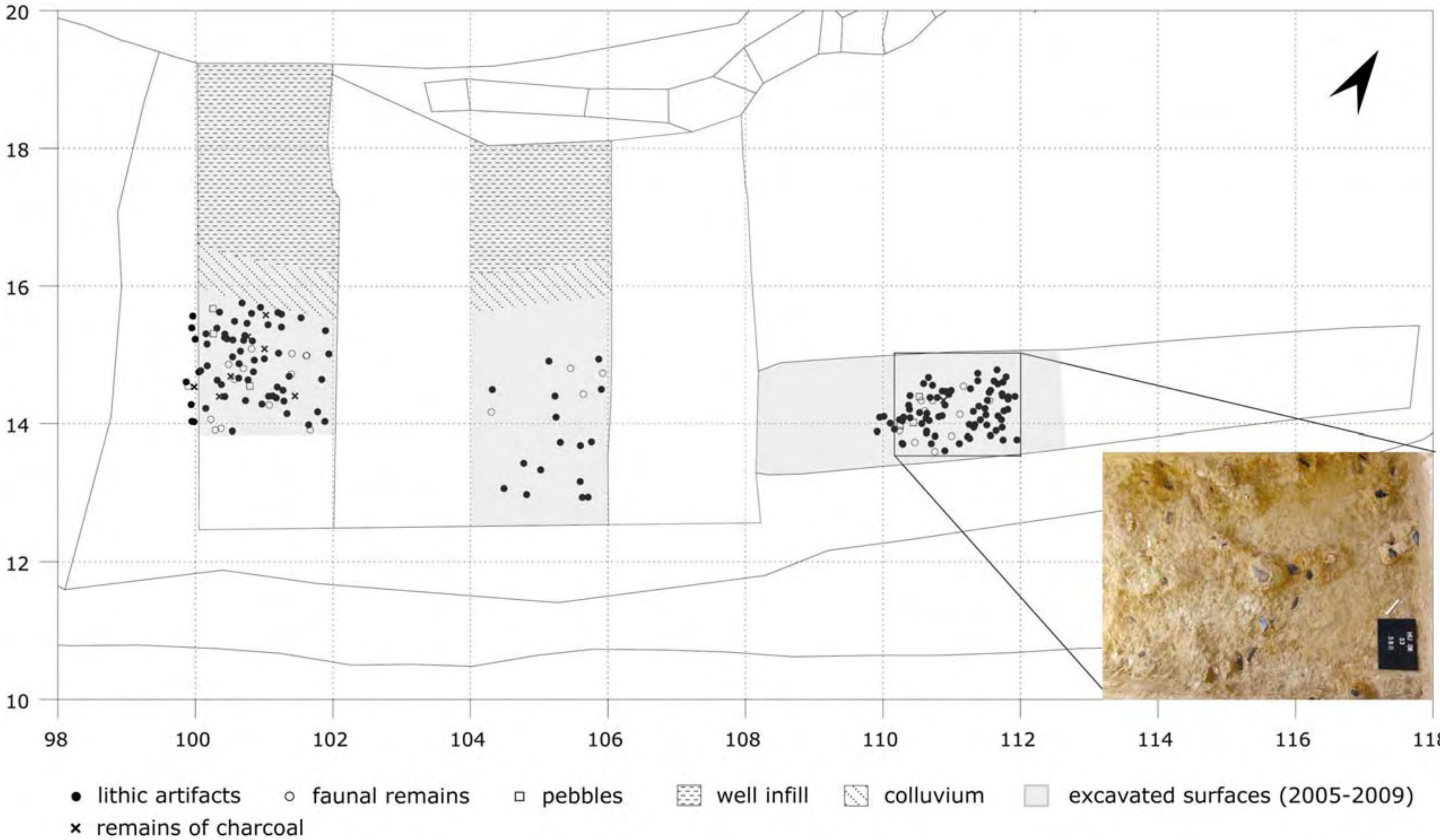


Fig.48: Horizontal distribution of archaeological remains in level 5BII. As in overlaying level 5BI, a remarkable find density was located in squares X=110-112/Y=13-14 in trench S3; the photo shows a section of one excavation planum.

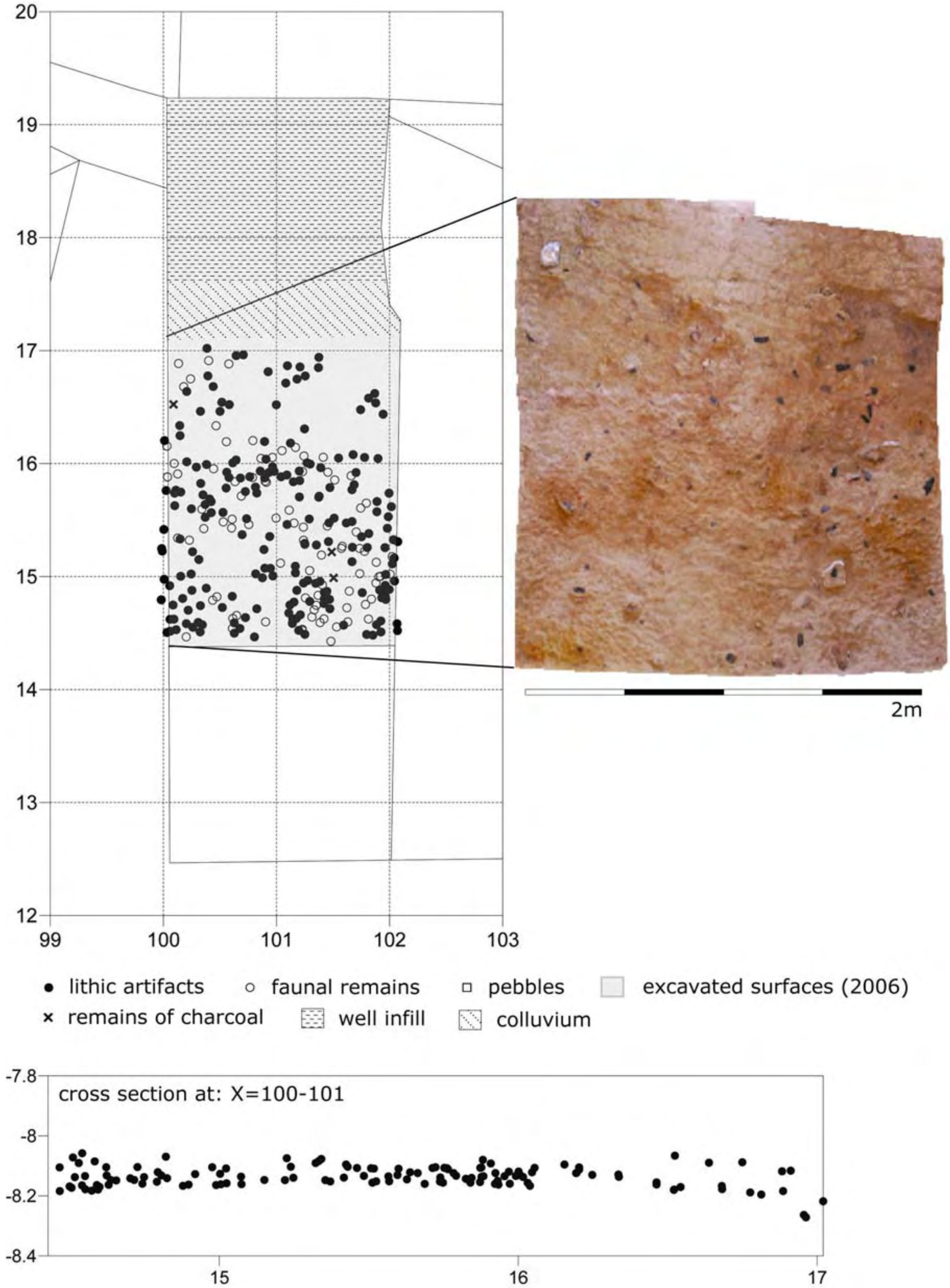


Fig.49: Horizontal distribution of vertical distribution of archaeological remains in level 5E (trench S1 excavation). The photo shows a section of one excavation planum.

Fig.49

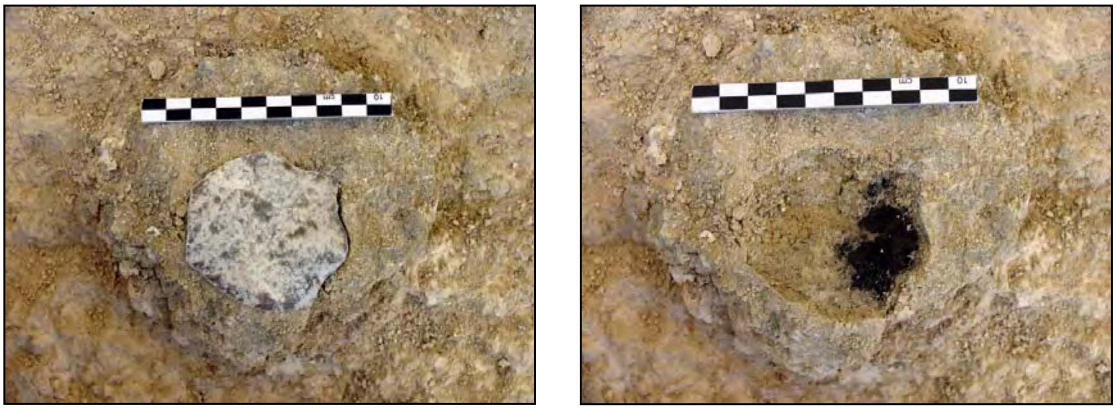


Fig.50: Possible evidence for the use of natural bitumen in level 5AIV (2007 excavation). The black substance was found attached to the proximal part of a Levallois flake and in the adjacent sediment.

Fig.50

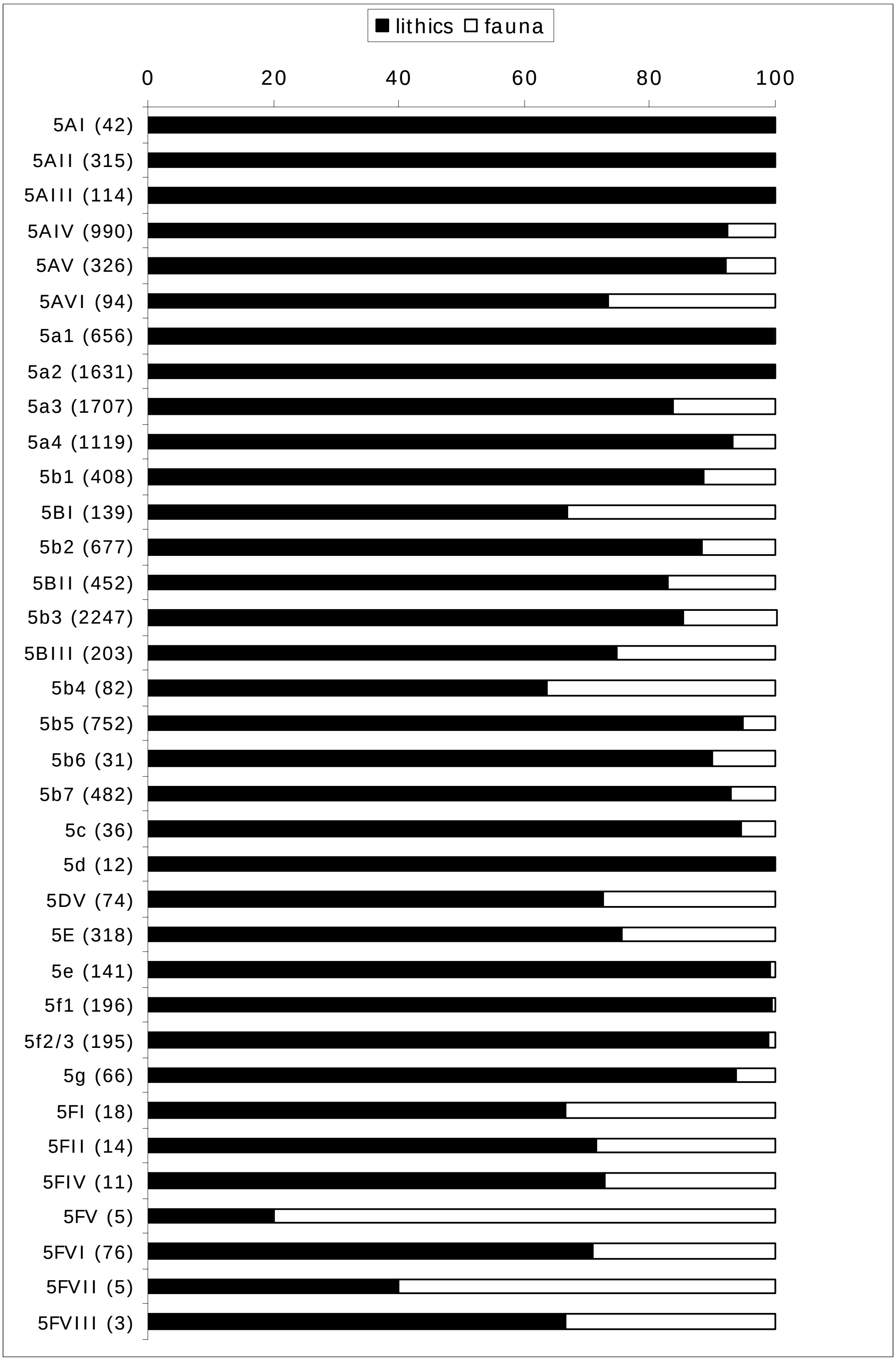


Fig.51: Proportion of lithic artifacts and animal bones in excavated Mousterian assemblages. Levels 5DII, 5DIII and 5DIV and are omitted due to low sample size.

Fig.51

Fig.52: Distal articulation of a camel tibia in level 5b3. Note the dissolution and fragmentation of bone material in the context of fissures filled with light-brown colored excrements of termites. The bone surface shows traces of intensive etching.

Fig.52

Fig.53

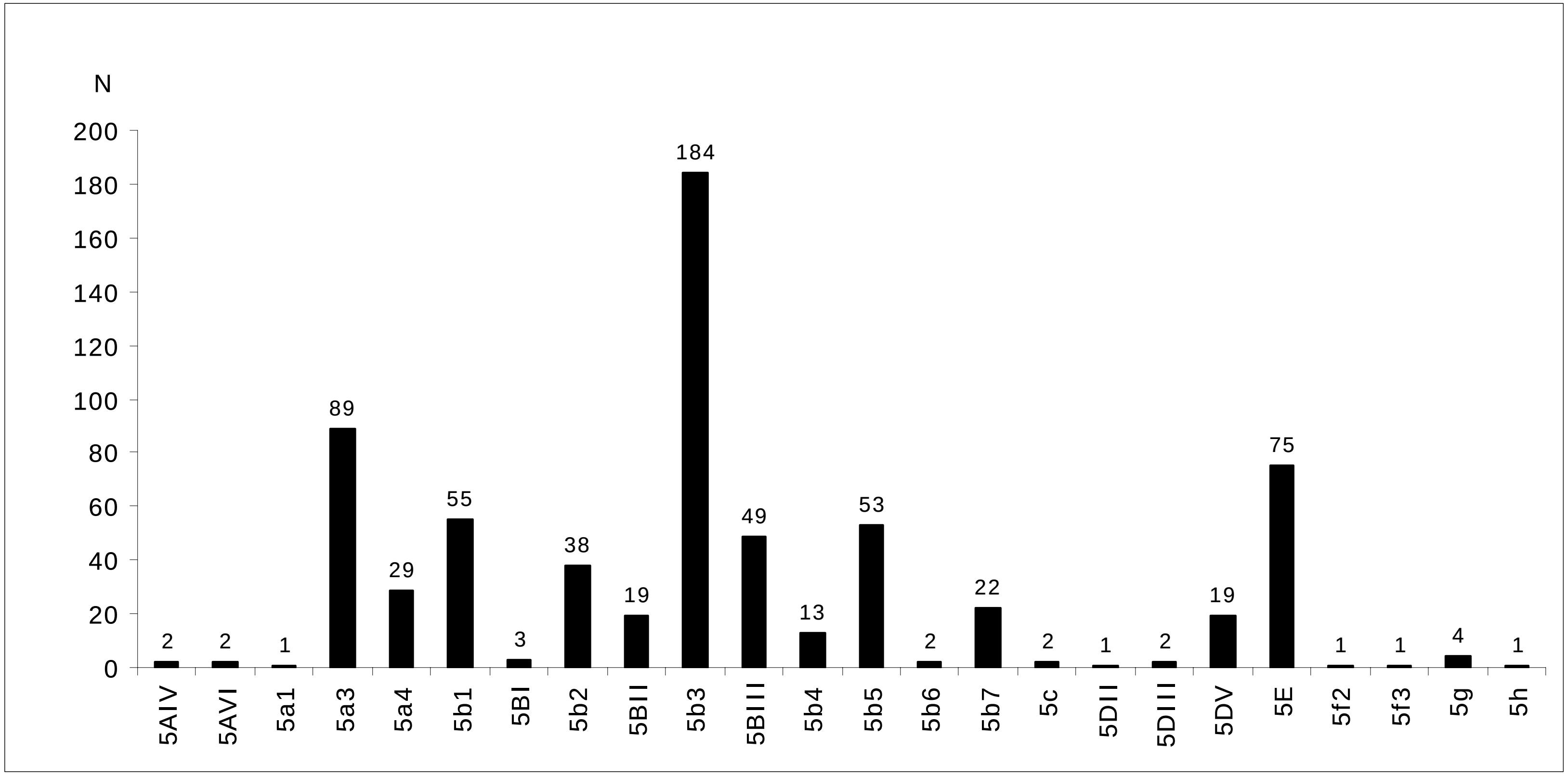


Fig.53: The size of analyzed faunal assemblages in selected Mousterian levels (analysis: P. Schmid); levels 5FI to 5FVII are not included as no data were available.

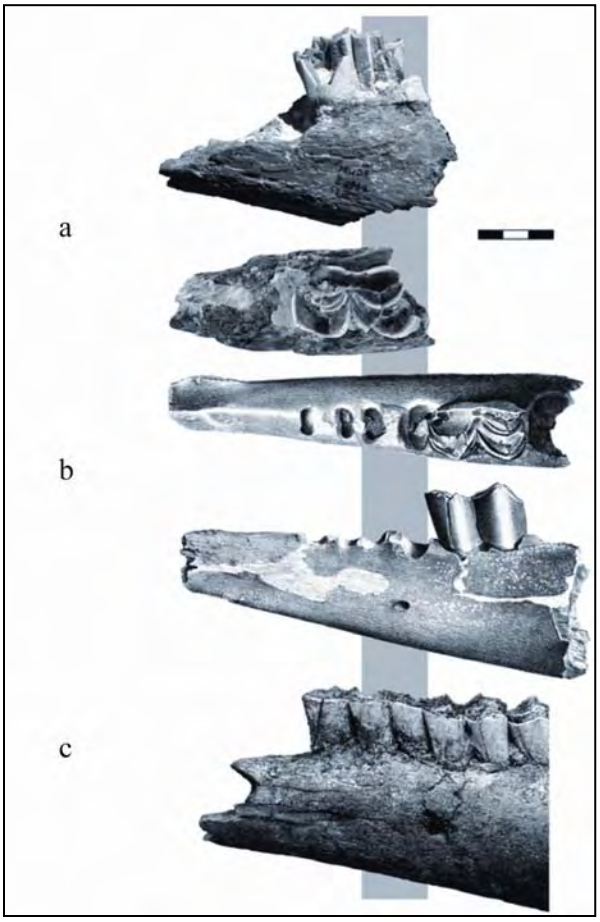


Fig.54: Left: Left manibular rami of (a) Camelus sp. nov. S2684 from Hummal layer 5b, (b) C. thomasii (after Pomel 1883), (c) C. dromedarius E6114 from Hummal layer 8a (Yabrudian). (a) and (b) in lateral and occlusal view, (c) only in lateral view; scale bar 3cm. The grey bar indicates the antero-posterior length of the alveoli for M_1 in Pomel's drawing (e.g. 25mm); right: proximal articulation of tibia of Camelus sp. Nov (left) and modern C.dromedaris (right). Source: figure reproduced with the kind permission of Peter Schmid.

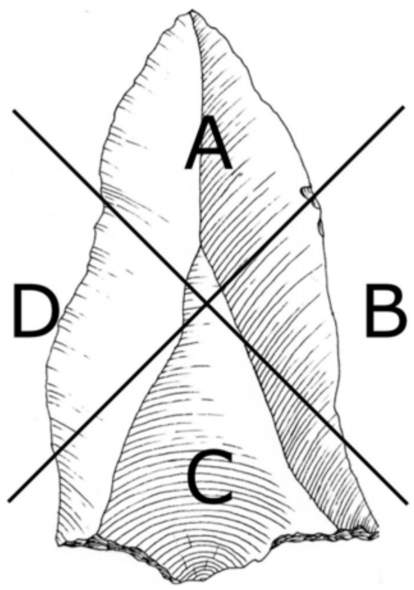
Fig.54

Fig.55: The human radial diaphyseal fragment found in Mousterian level 5b1 and its comparison with complete radii of modern humans (left) and Neandertals (right). Source and copyright: Peter Schmid.

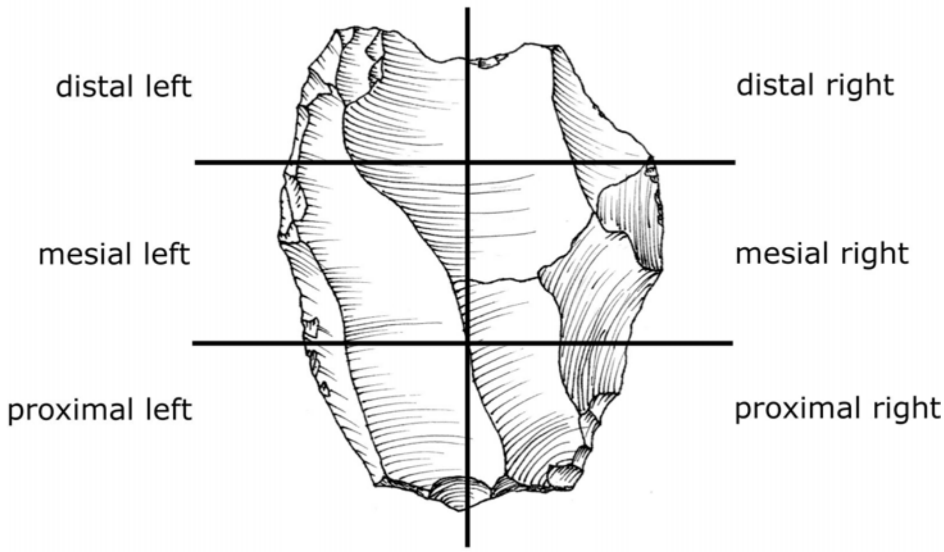
Fig.55

Fig.56: The medial left upper incisor found in Mousterian level 5a4. The length of its root and crown's shape warrant an attribution to *H. neanderthalensis.* Source and copyright: Peter Schmid.

Fig.56



①



②

Fig.57: Analytical schemes for complete flakes. Nr.1: division of sectors for the count of dorsal negatives and the determination of dorsal scar patterns; Nr.2: division of sectors for determining the location of edge damage, cortex and modifications (according to Tostevin 2003). The measurement of edge angles and the determination of edge cross section types works with a division in four sectors: distal left, distal right, proximal left and proximal right.

Fig.57

Fig.58

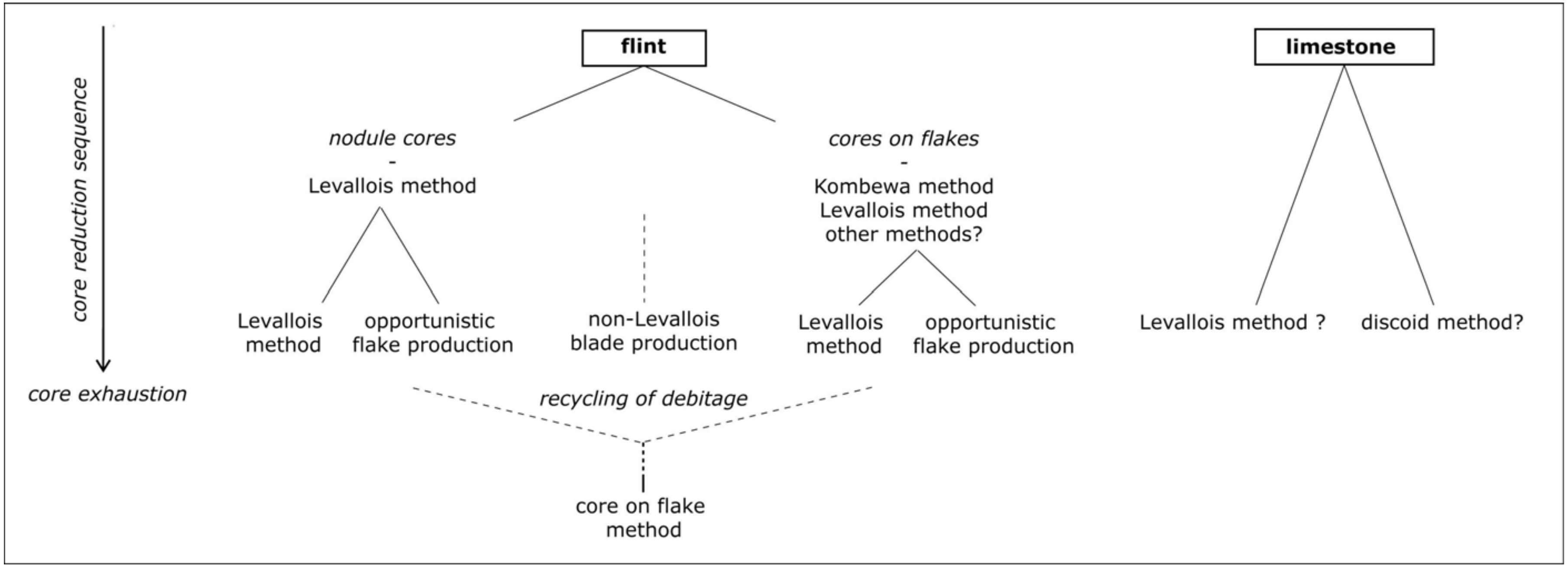


Fig.58: Variable modes of core reduction identified in the Mousterian assemblages of Hummal and their relationship to the type of raw material. Nodule cores were either reduced completely by the Levallois method or turned into simple flake cores for opportunistic blank production in the final reduction stage. The core on flake method was applied as an alternative reduction strategy from the beginning or as a secondary recycling strategy; limestone pebbles were exploited with a Levallois or discoid-like method.

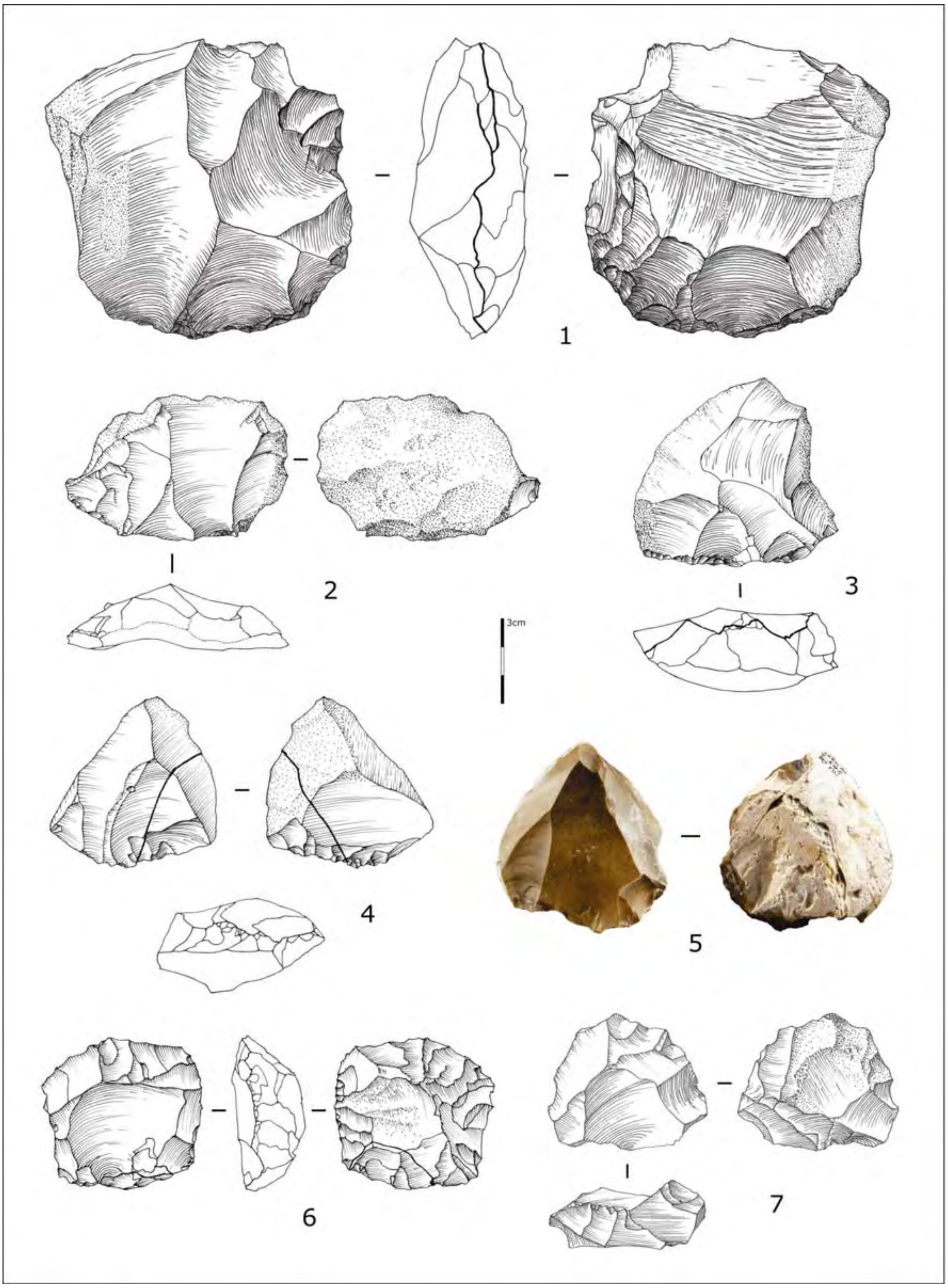


Fig.59: Different Levallois core types. Nr.1: large Levallois flake core with semi-centripetal removals (archaeological complex 5b); Nr.2: unidirectional-parallel Levallois blade core (level 5AIV); Nr.3-5: Levallois point cores (Nr.3: level 5a2, Nr.4: level 5AII, Nr.5: level 5b5); Nr.6-7, preferential Levallois flake cores (Nr.6: level 5e, Nr.7: level 5b5).

Fig.59

Fig.60

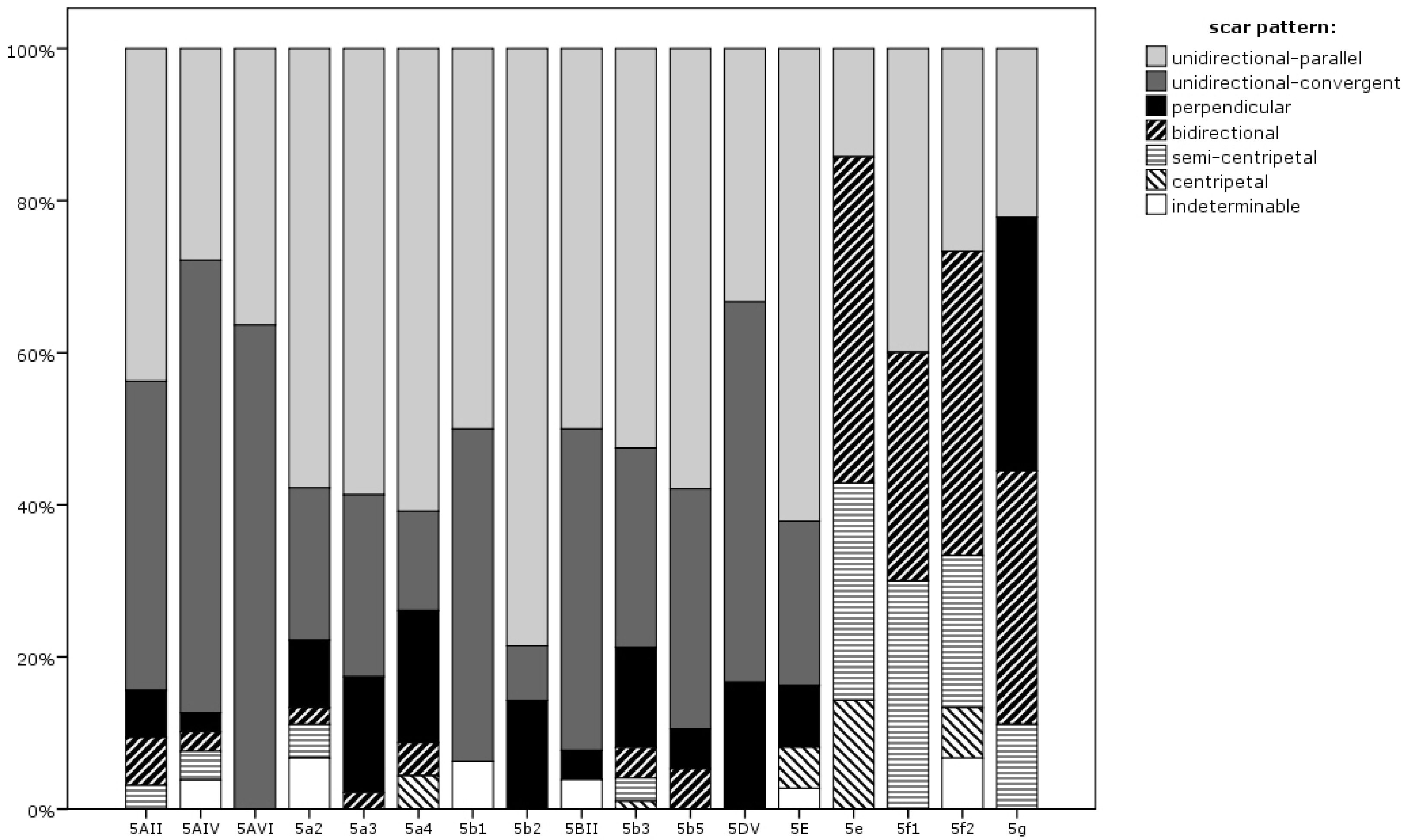


Fig.60: Levallois flakes and blades in selected Mousterian assemblages: frequency of scar patterns; levels 5b4 and 5b7 are not included due to a lack of results; assemblage 5a1 is excluded because of a possible contamination.

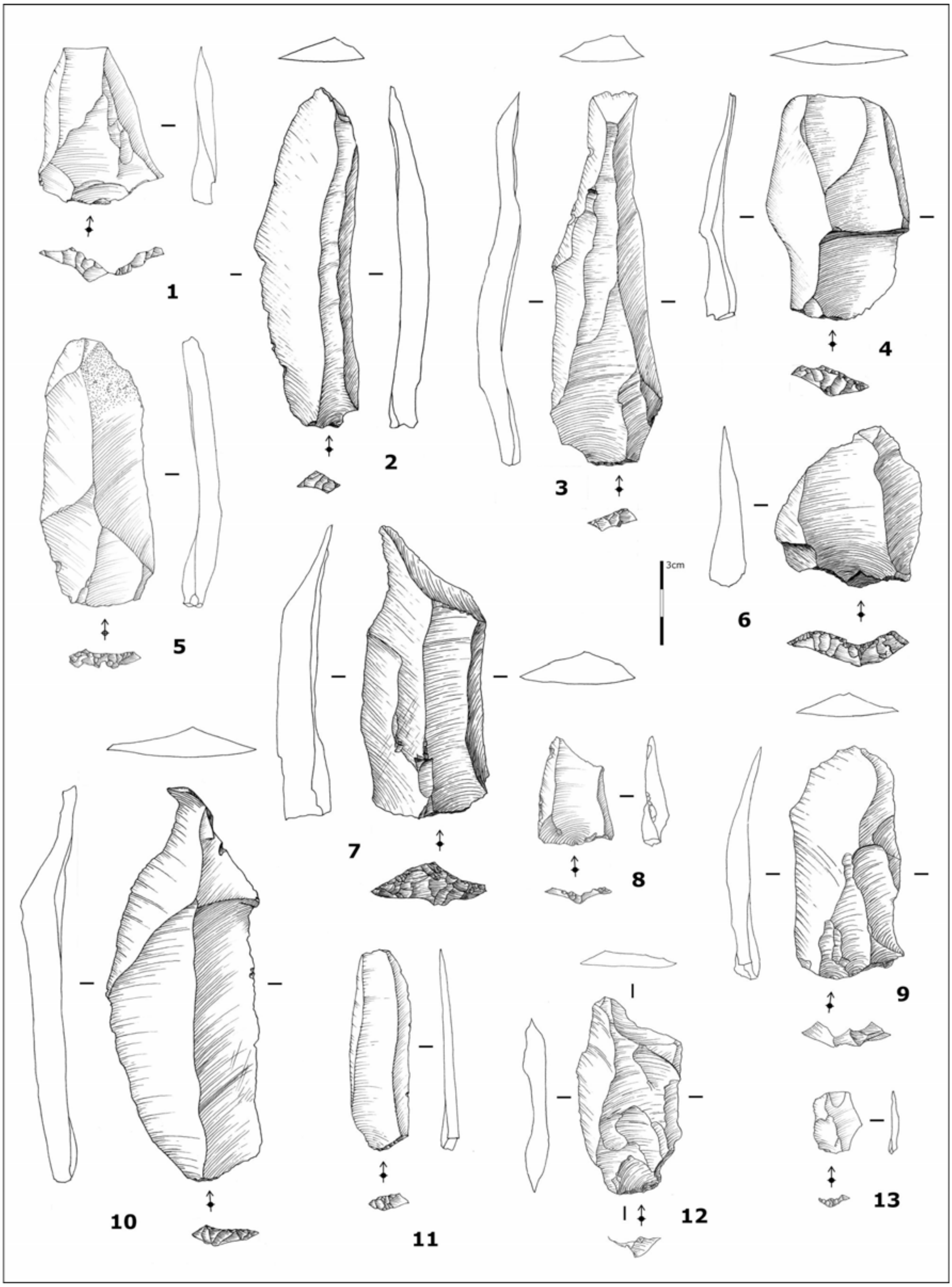


Fig.61: Levallois flakes and blades produced with the recurrent unidirectional method. Note the gradual shift between parallel and convergent scar patterns which reflects the close technological relationship between Levallois point and flake / blade production; (Nr.1: level 5a4; Nr.2: complex 5b; Nr.3, 4, 9, 10, 12: level 5b3; Nr.5: level 5b1; Nr.6: level 5a3; Nr.7: level 5b2; Nr.8, 13: level 5b5; Nr.11: level 5E).

Fig.61

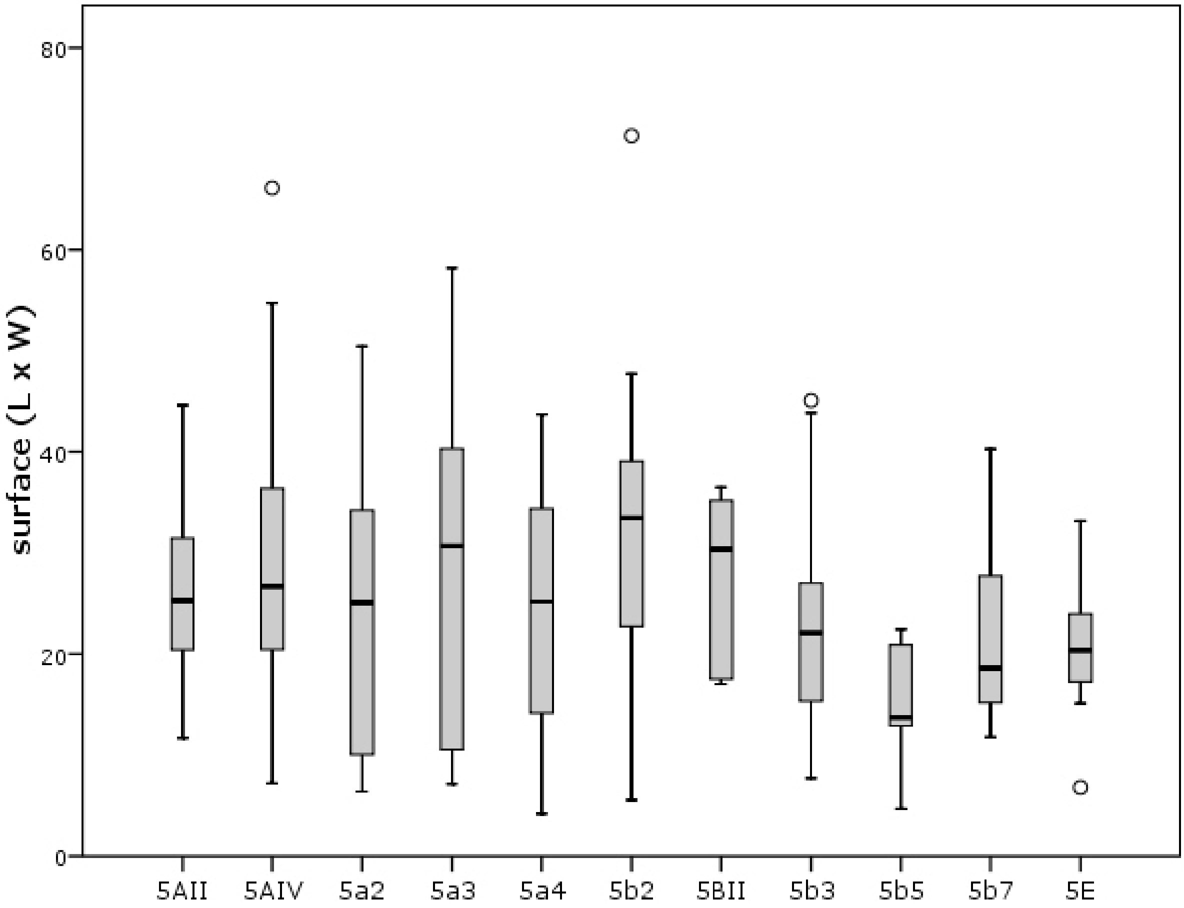


Fig.62: Boxplot showing the surface size range of Levallois points in selected Mousterian assemblages (N>5). Surface size in cm^2 is obtained by multiplying artifact length with artifact width.

Fig.62

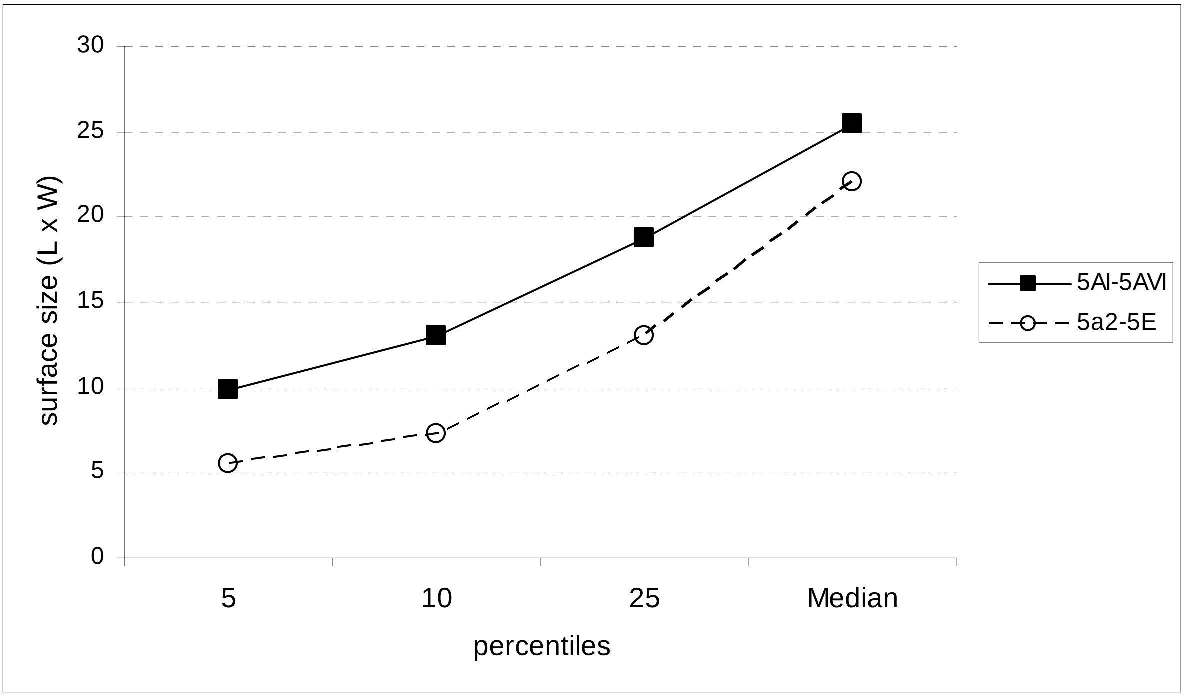
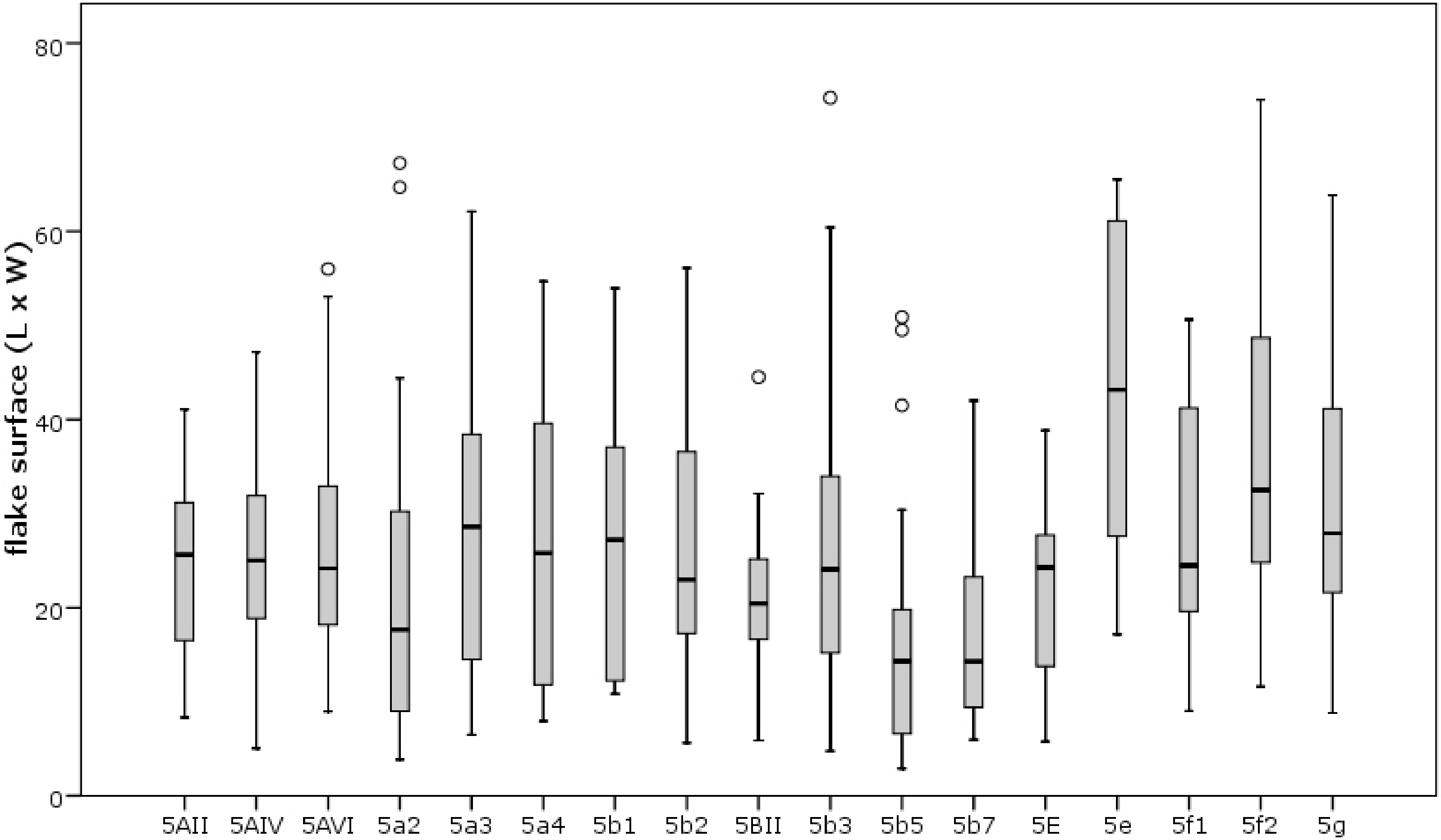


Fig.63: Examination of the lower surface size range of Levallois points: position of the 5th, 10th, 25th percentiles and the median of surface size values of assemblage groups generated by the two varieties of recurrent point production.

Fig.63

Fig.64



inter-assemblage variability: ANOVA: $F = 2.826$; $p = 0.00$

Fig.64: Boxplot showing the range of surface size values for Levallois flakes and blades in selected assemblages (N>6). Levels 5AI, 5AIII, 5AV, 5BI, 5b4, 5b6, 5c, 5d, and 5DV are not included due to insufficient data; level 5a1 is not included due to possible contamination.

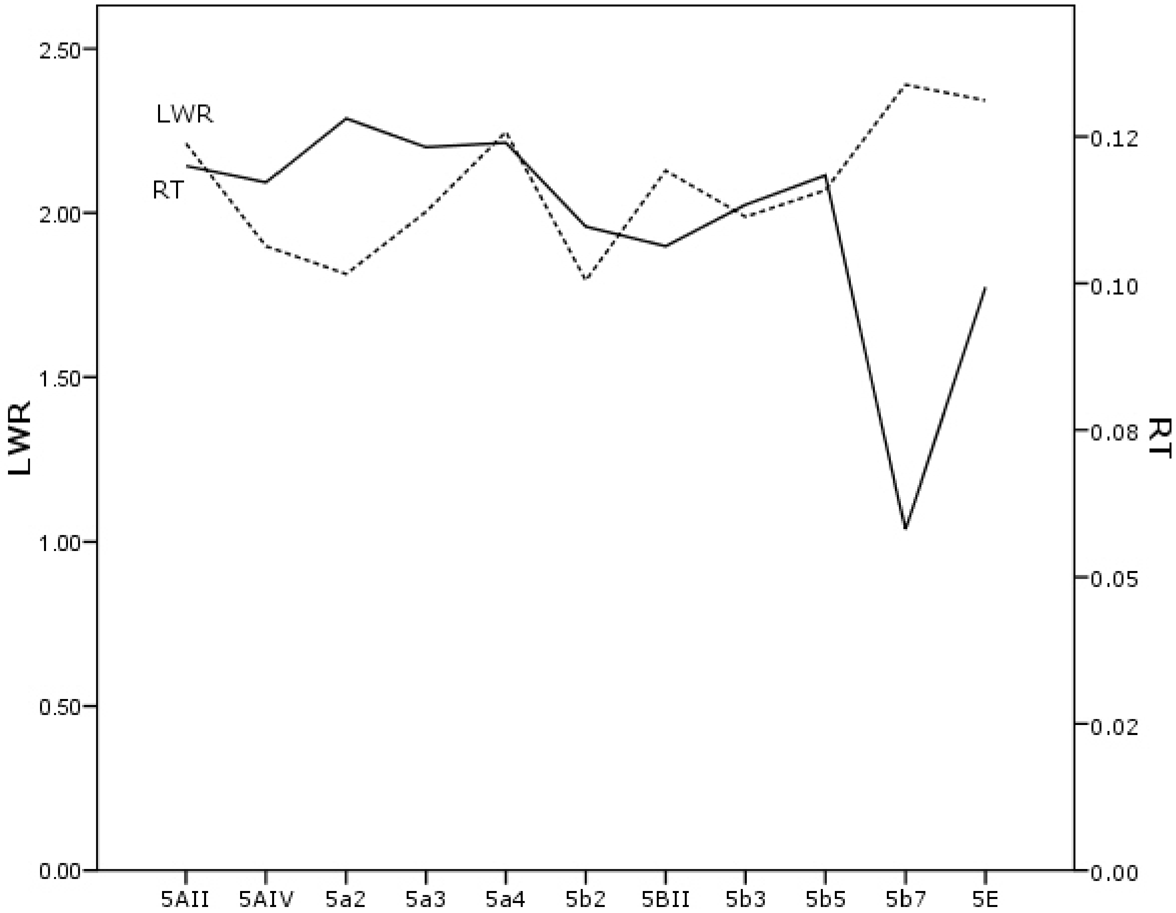


Fig.65: Comparison between the mean length width ratio (LWR) and mean relative thickness (RT) of Levallois points in selected Mousterian assemblages.

Fig.65

Fig.66

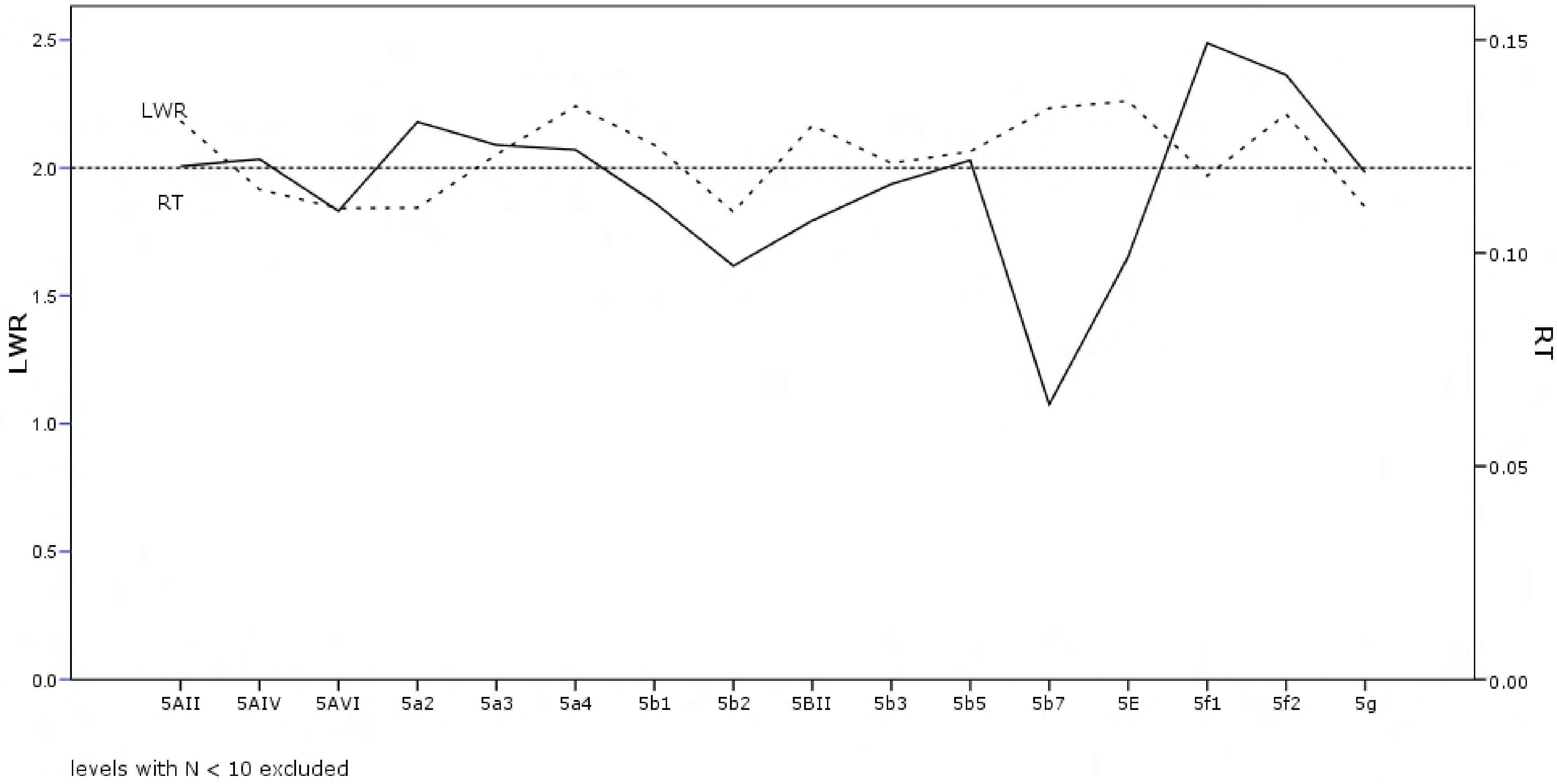


Fig.66: Comparison between the mean length width ratio (LWR) and mean relative thickness (RT) for Levallois flakes and blades in selected Mousterian assemblages. Levels 5AI, 5AIII, 5AV, 5BI, 5b4, 5b6, 5c, 5d, and 5DV are not included due to insufficient data; level 5a1 is not included due to possible contamination.

Fig.67

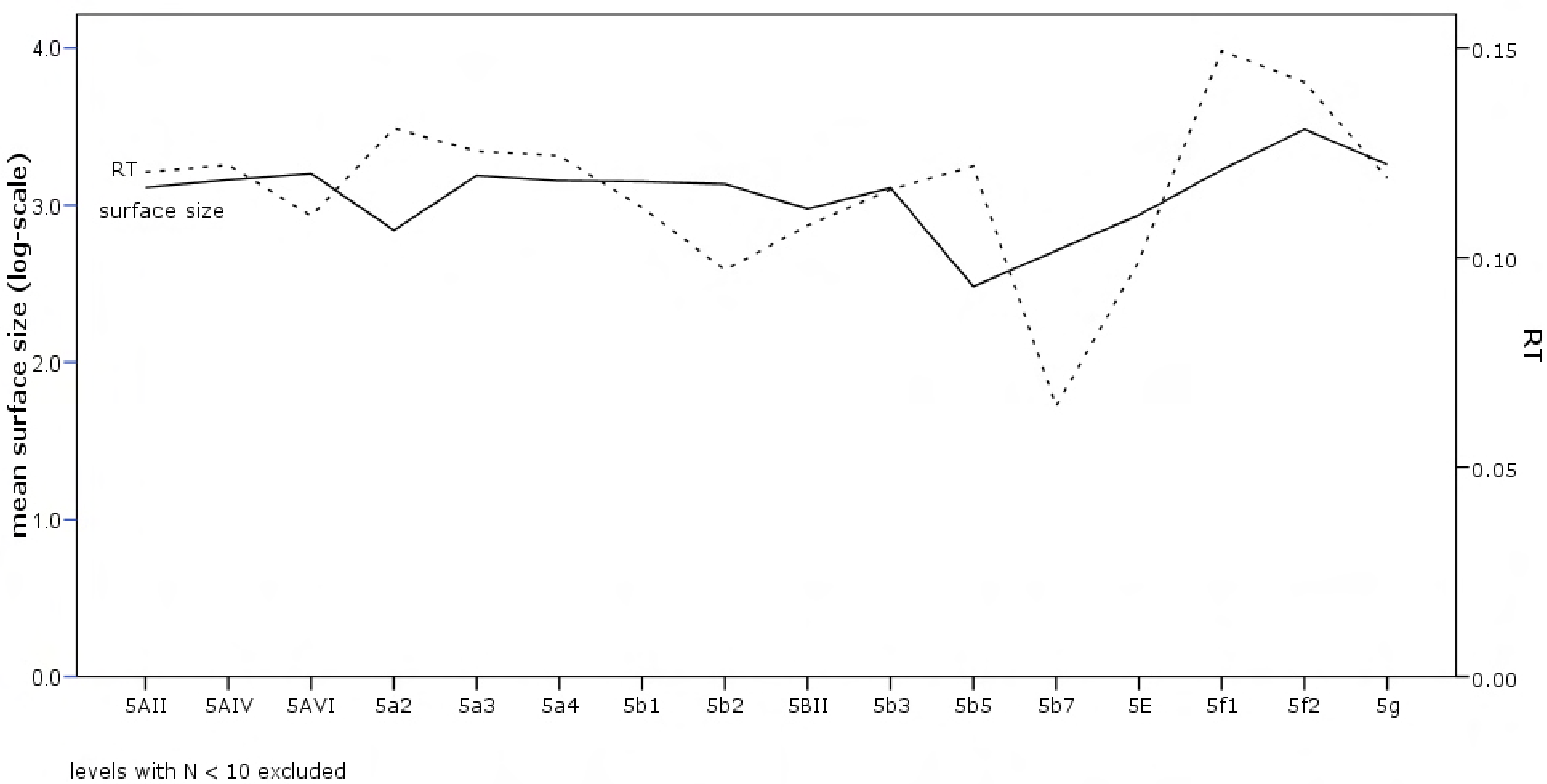


Fig.67: Comparison between the mean surface size (logarithmic scale) and mean relative thickness (RT) for Levallois flakes and blades in selected Mousterian assemblages. Levels 5AI, 5AIII, 5AV, 5BI, 5b4, 5b6, 5c, 5d, and 5DV are not included due to insufficient data; level 5a1 is not included due to possible contamination.

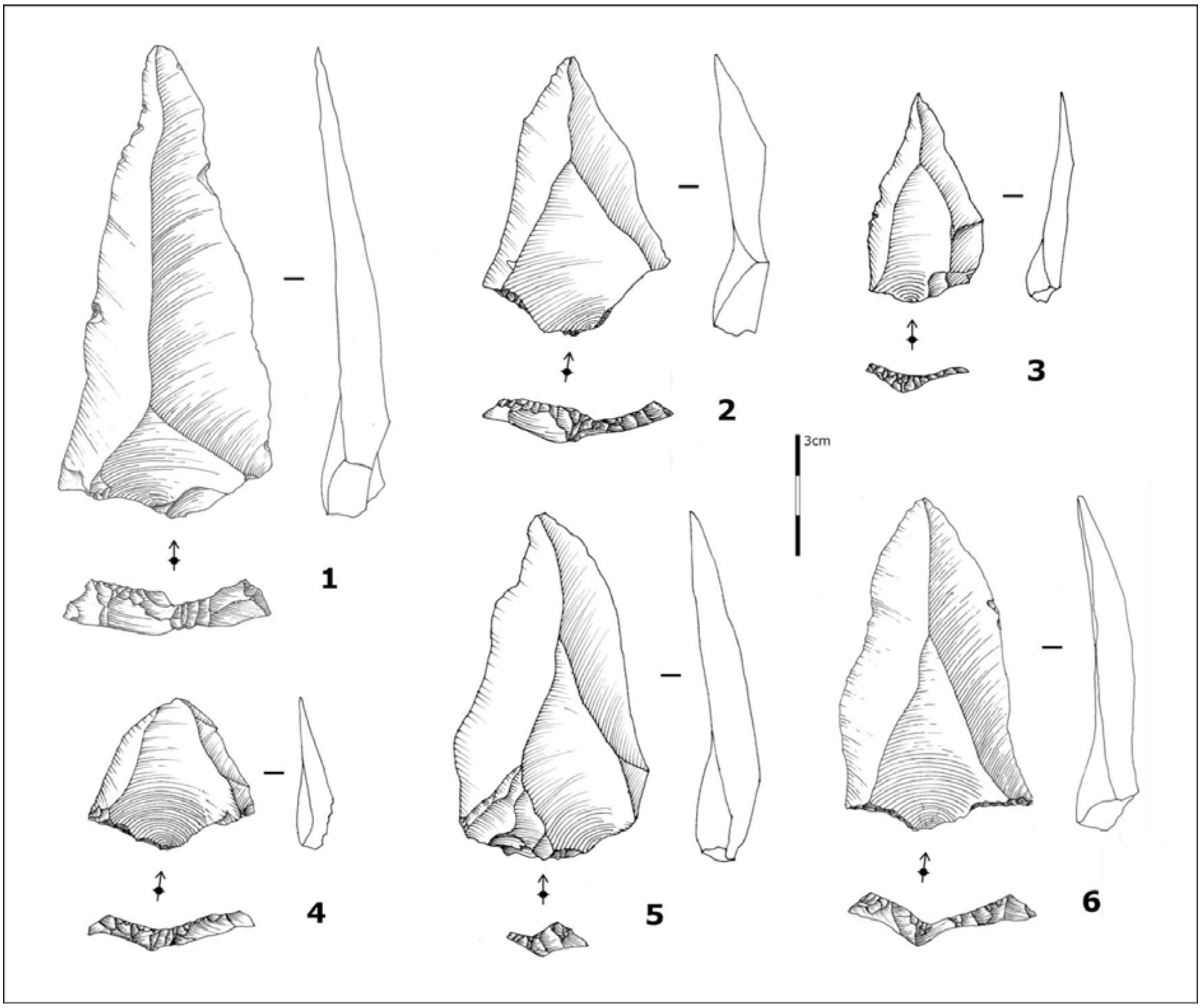


Fig.68: “Classical” Levallois points in selected Mousterian assemblages (Nr.1: level 5a4; Nr.2: level 5AVI; Nr.3: level 5b5; Nr.4: level 5AIV; Nr.5: level 5DV; Nr.6: level 5a3).

Fig.68

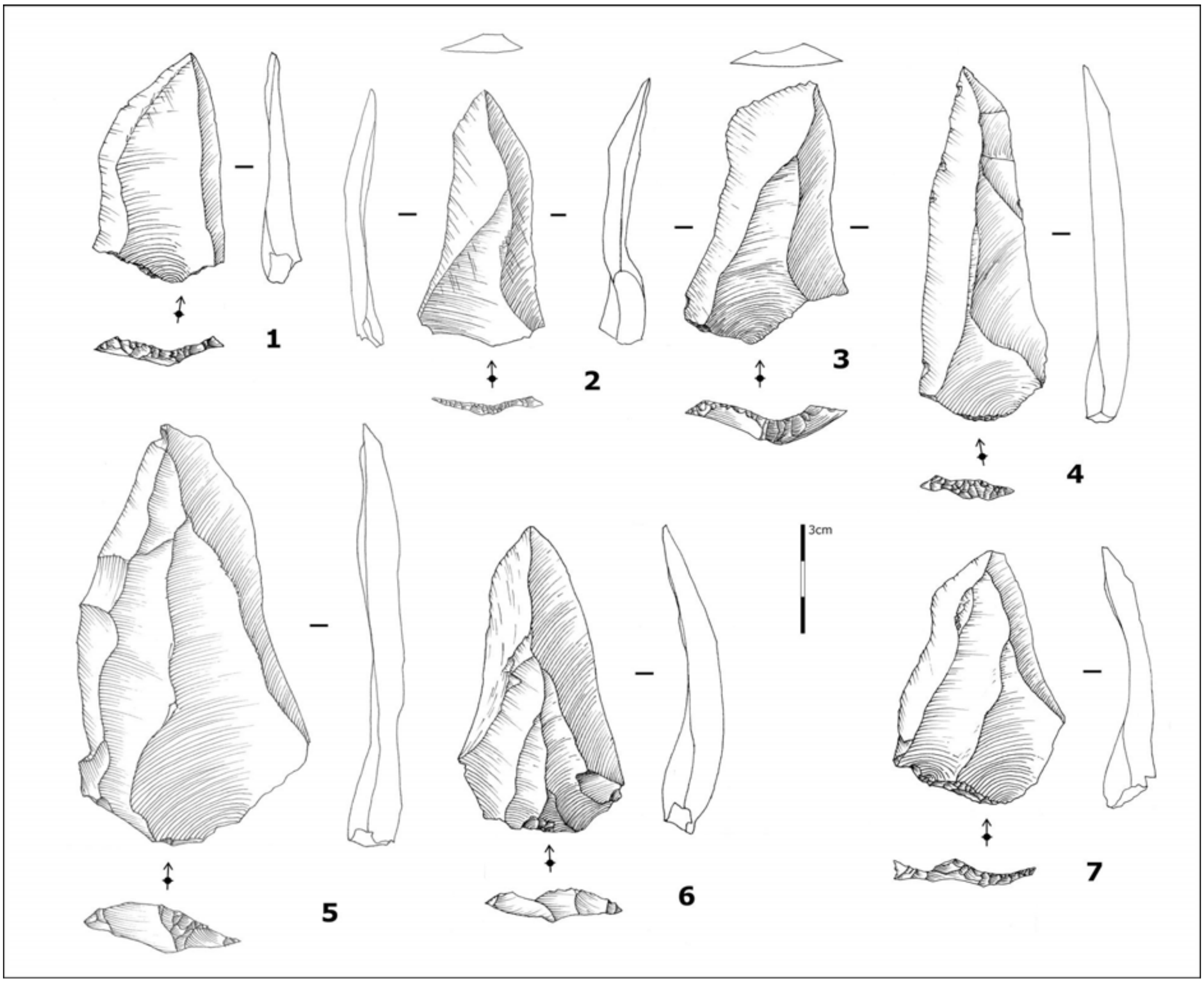


Fig.69: Levallois points produced with the recurrent method (Nr. 1-4) and “constructed” Levallois points (Nr. 5-7). (Nr.1: level 5a2; Nr.2-3: level 5b3; Nr.4: level 5E; Nr.5: level 5AVI; Nr.6: level 5AII; Nr.7: level 5AIV).

Fig.69

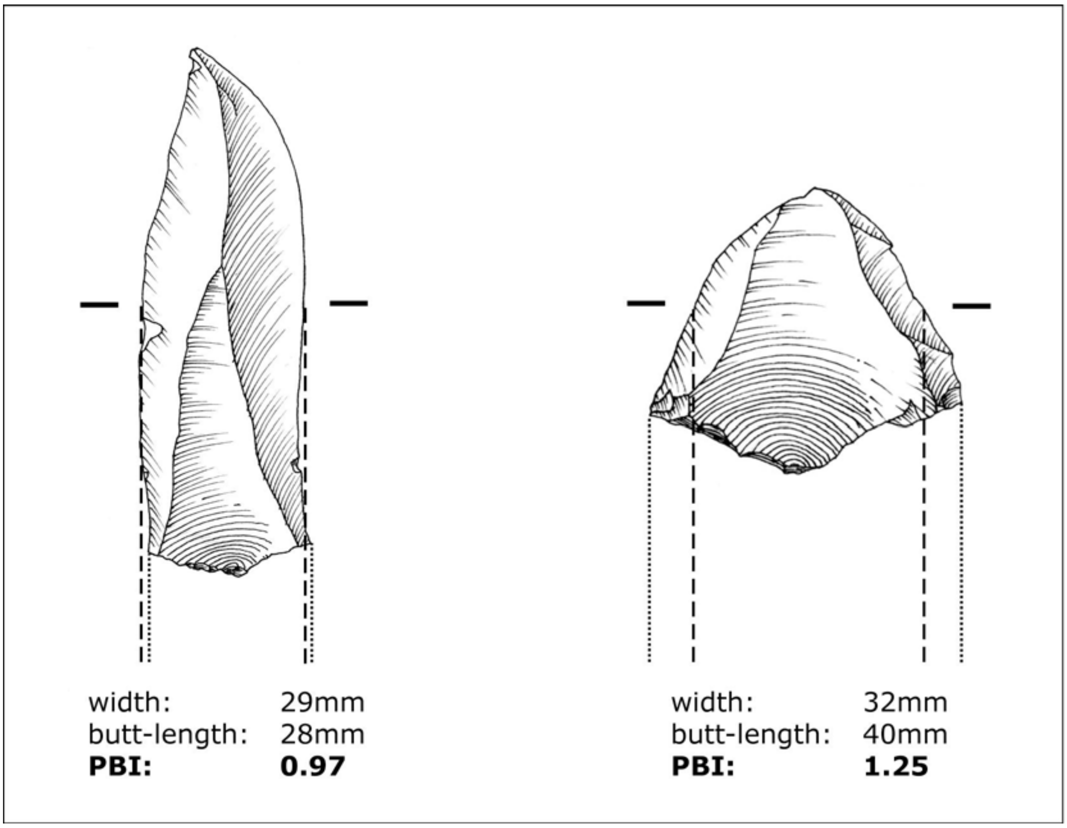


Fig.70: Measurement of the width at the artifact's midpoint and butt-length at its base for the calculation of the proximal breadth index (PBI) for Levallois points.

Fig.70

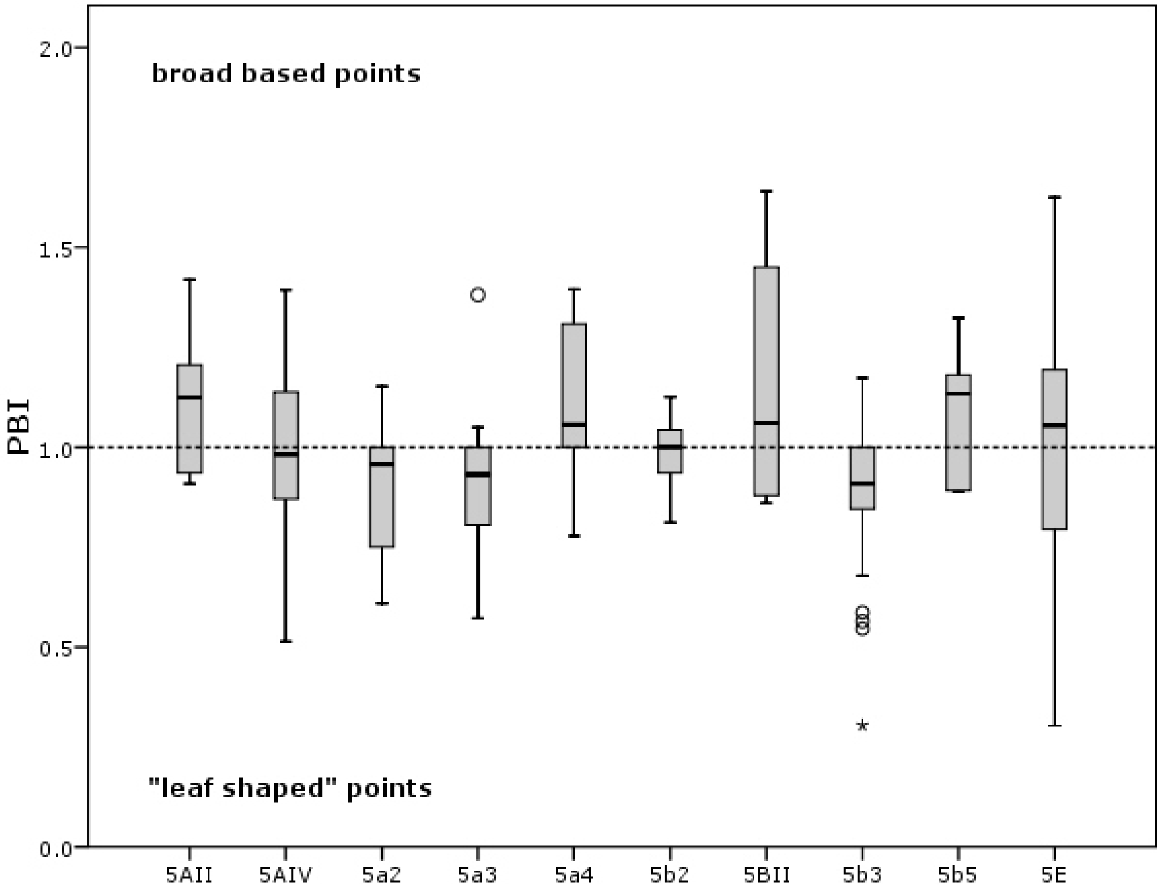


Fig.71: Boxplot showing the range and median of PBI values in major Levallois point-bearing assemblages (levels with N<5 points excluded). Levallois points with a PBI value over 1.0 can be considered as broad based specimens, whereas points with values < 1.0 are "leaf shaped" specimens.

Fig.71

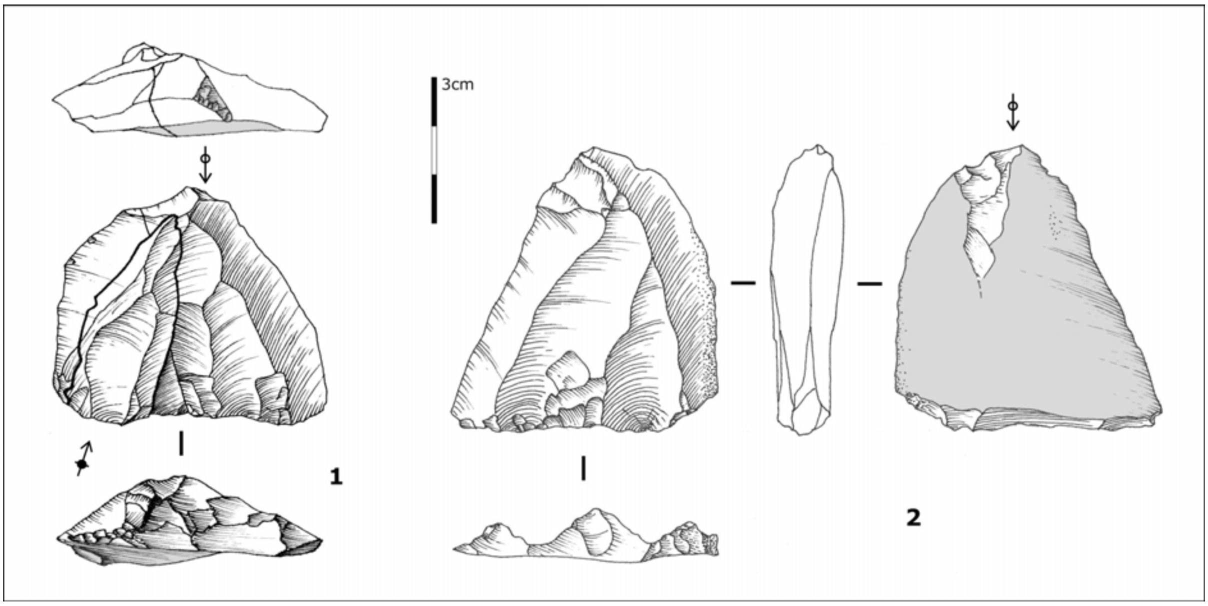


Fig.72: Recurrent Levallois point cores on flakes. The cores were prepared out of large flake fragments and exploited in opposite direction to the blank’s former flaking axis; the blanks’ ventral surface is highlighted in grey color; Nr.1 shows a point core on which an atypical Levallois point was refitted (Nr.1: level 5a3; Nr.2: level 5b5).

Fig.72

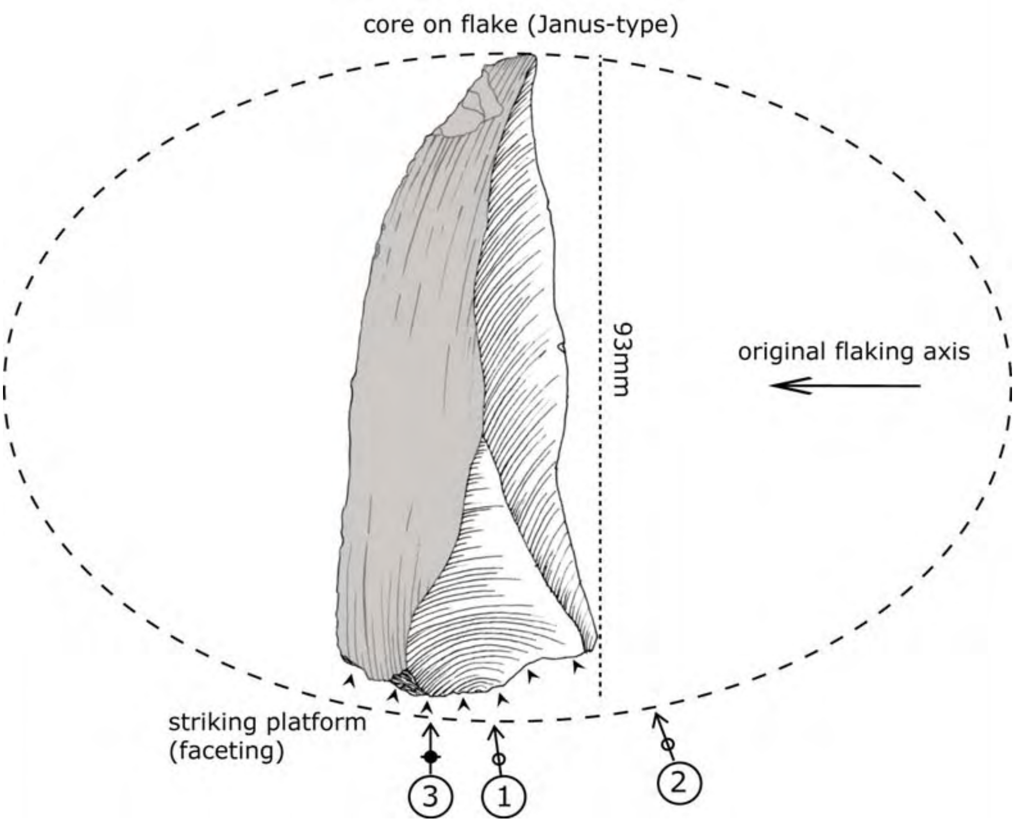


Fig.73: “Janus-type” Levallois point (Nr. 1369, level 5AII) and the theoretical dimension of the core on flake from which it was struck. The part of the former ventral surface is indicated in grey color; part of parent flakes’ edge is removed by platform faceting. A series of at least two anterior removals is indicated by the negatives visible on the Levallois point.

Fig.73

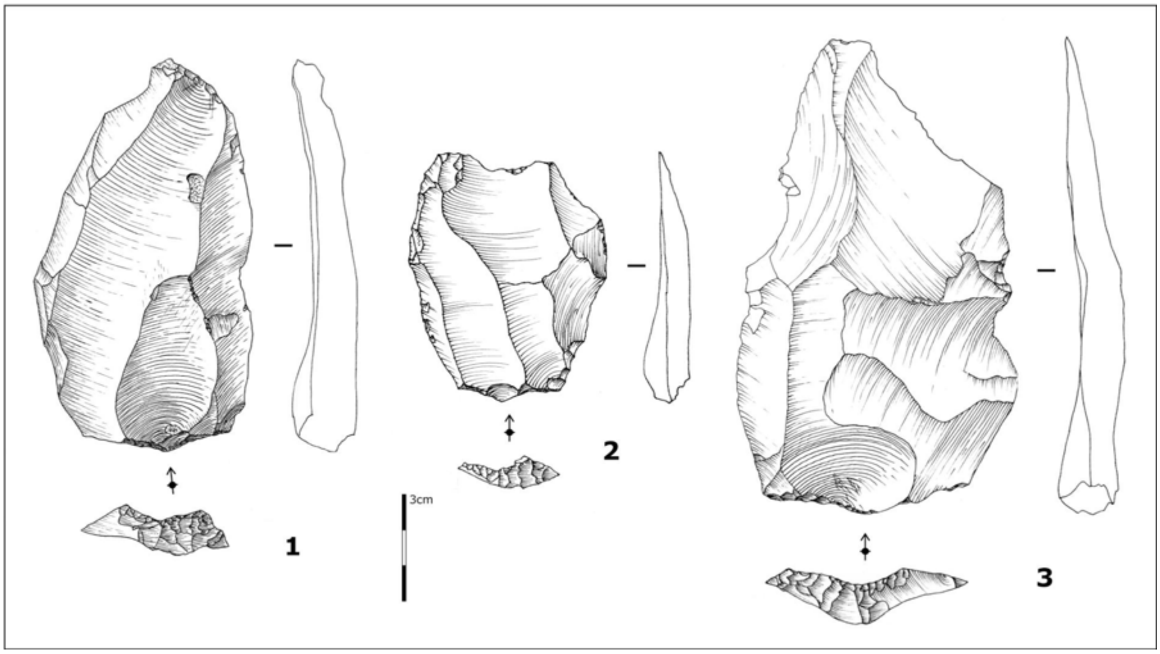


Fig.74: Levallois flakes produced with the bidirectional and centripetal flaking method (Nr.1: level 5e; Nr.2-3: level 5f2/3).

Fig.74

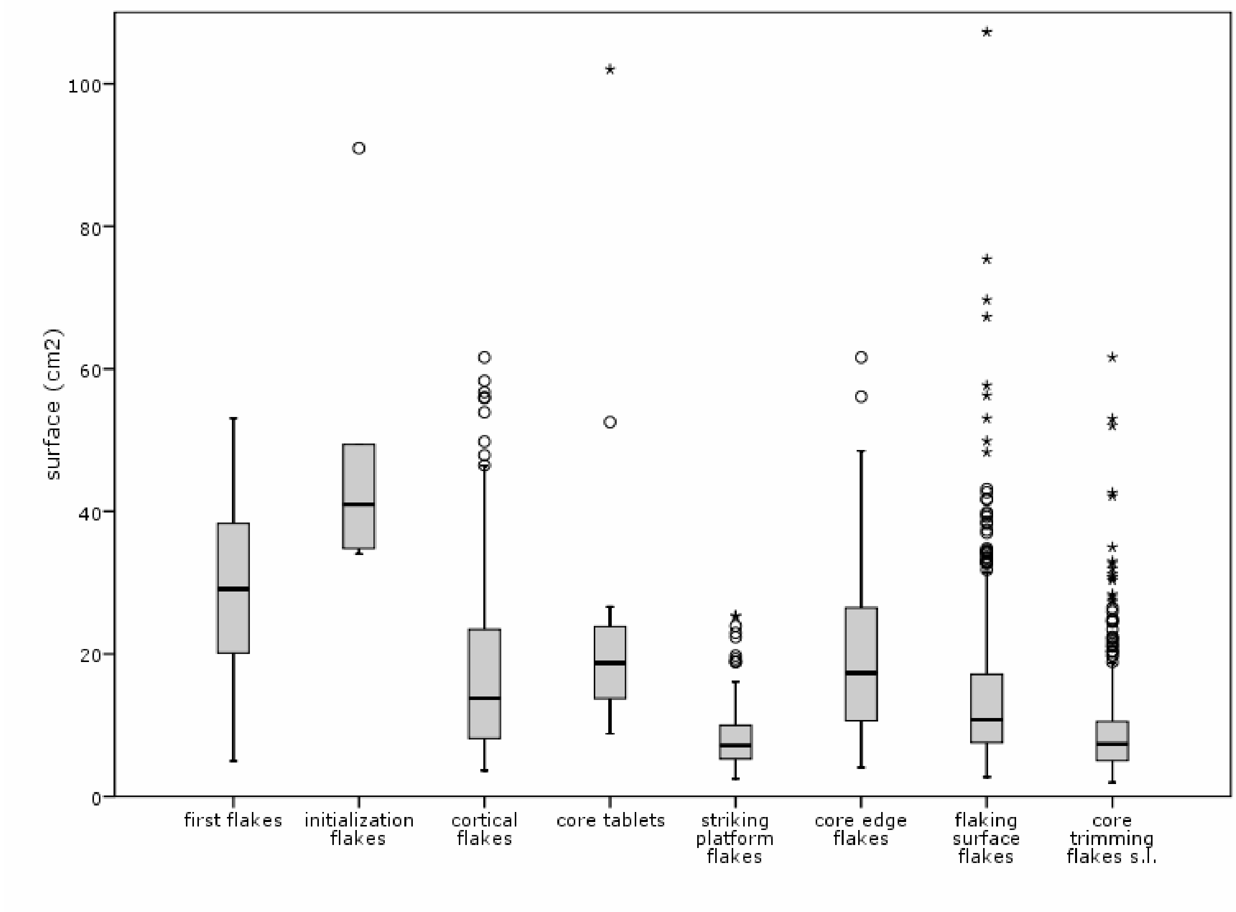


Fig.75: Boxplot showing the surface size range of different CTE categories measured in cm2.

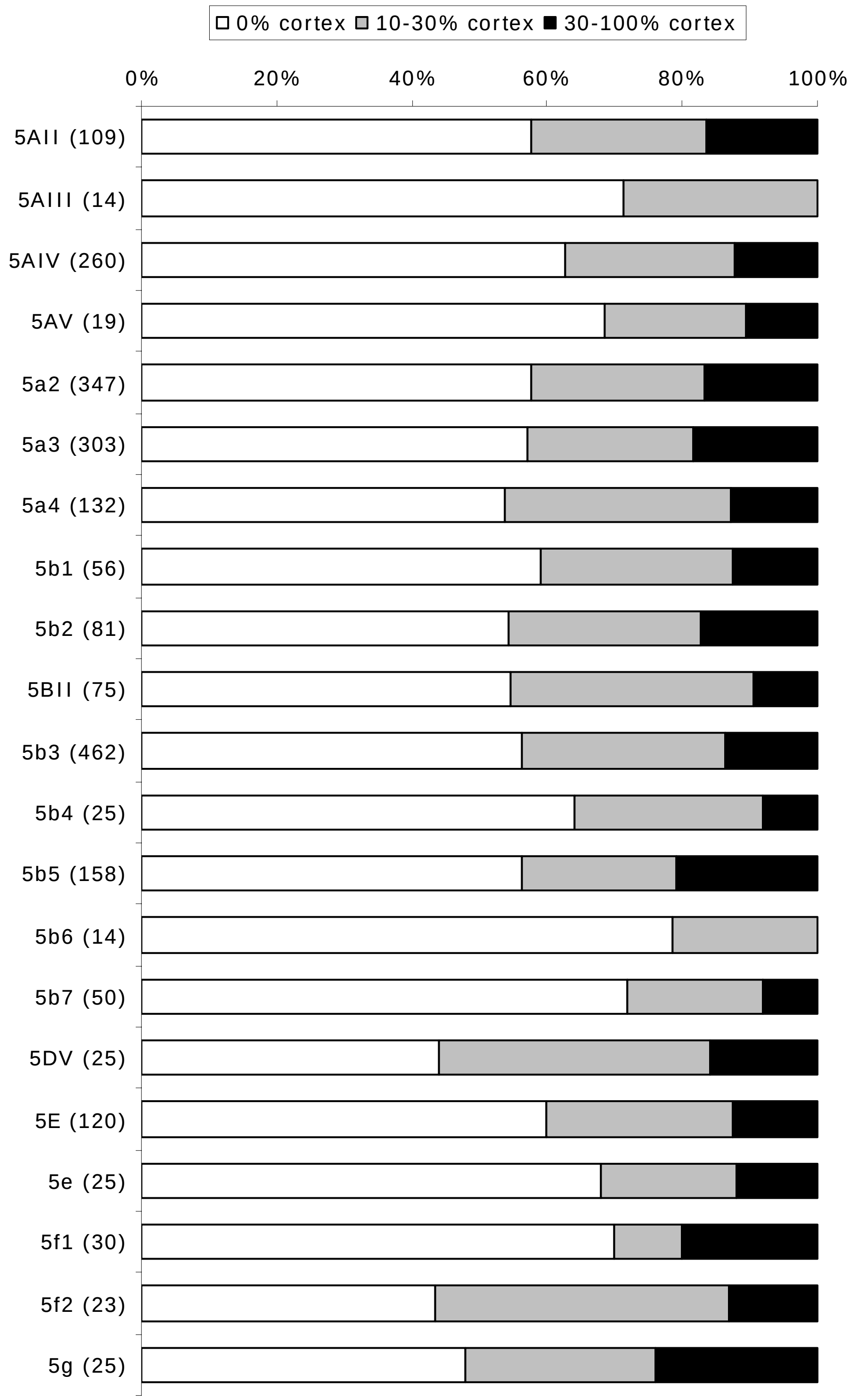
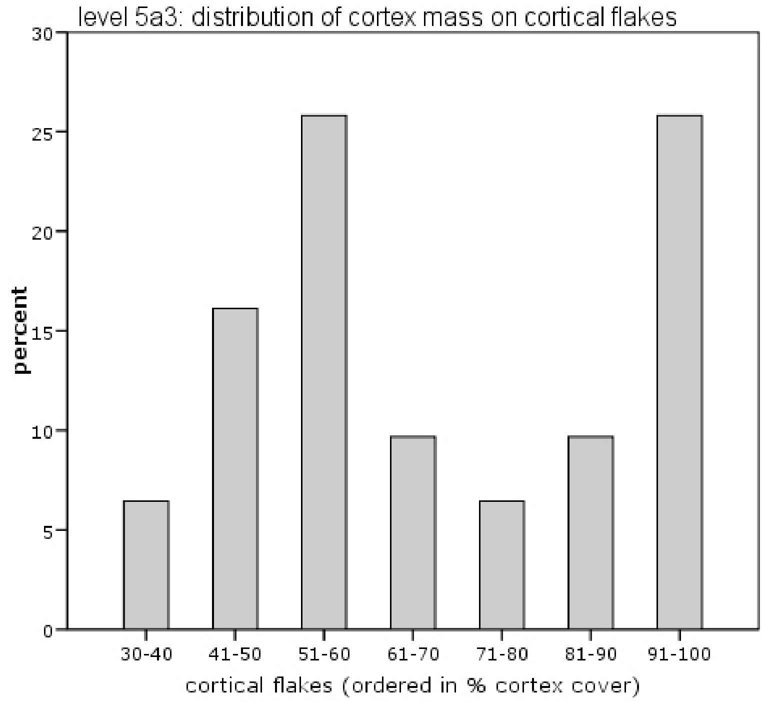


Fig.76: The frequency distribution of non-cortical flakes and cortical flakes in selected Mousterian assemblages (N>10; see text for the definition of categories).

Fig.76



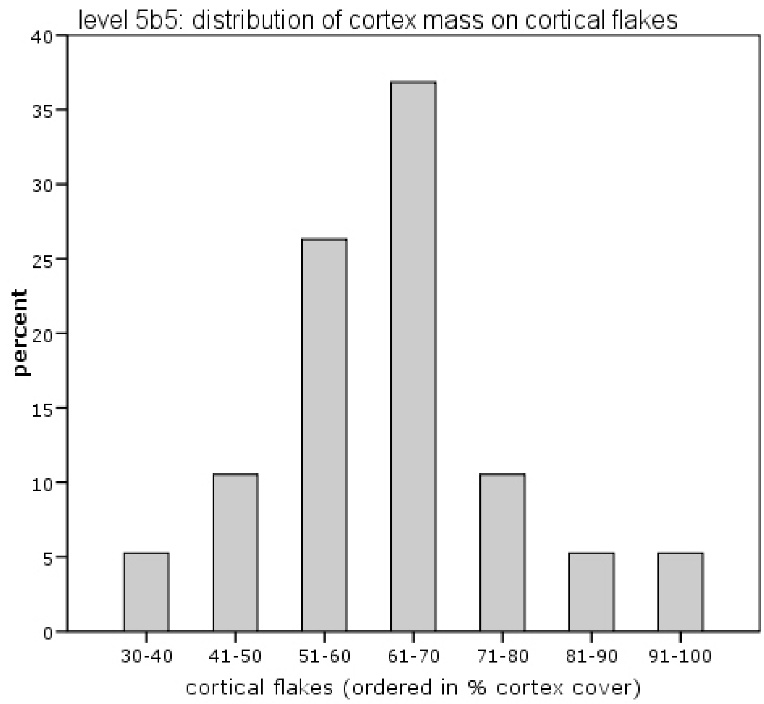


Fig.77: Comparison between levels 5a3 (A) and 5b5 (B) in respect to cortex mass distribution among cortical flakes; assemblage 5a3: N=31; assemblage 5b5: N=29.

Fig.77

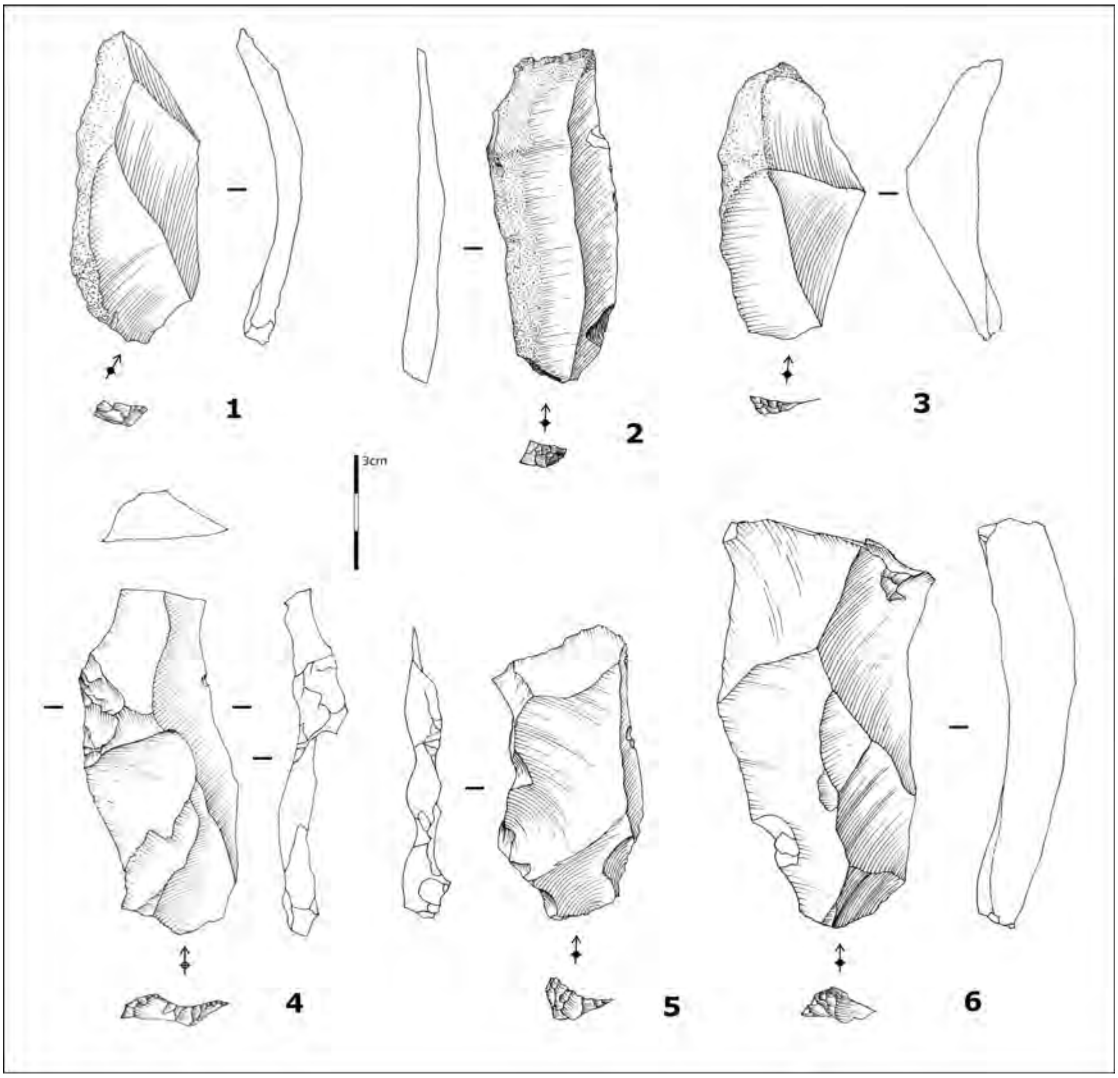


Fig.78: Naturally backed knives and core edge flakes: 1-3, naturally backed knives (Nr.1: level 5b3; Nr.2: level 5a3; Nr.3: level 5AII); 4-5, core edge flakes (level 5a3); 6, core tablet (level 5AIV).

Fig.78

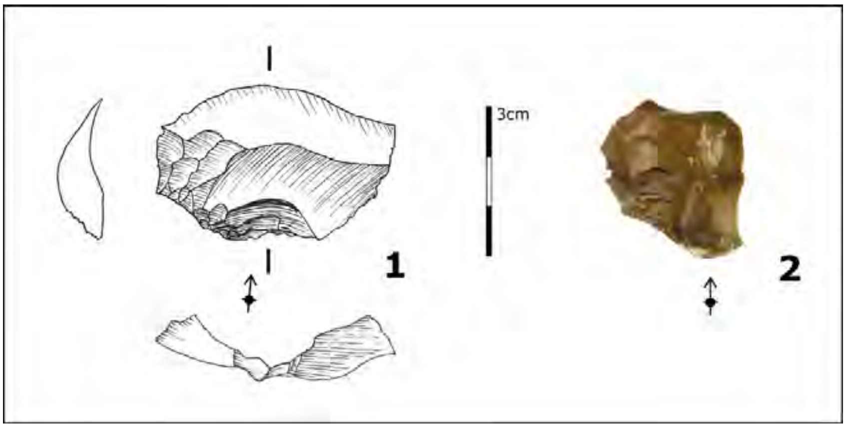


Fig.79: Two examples of striking platform flakes (level 5b3). Note the small scars in the proximal part stemming from platform faceting.

Fig.79

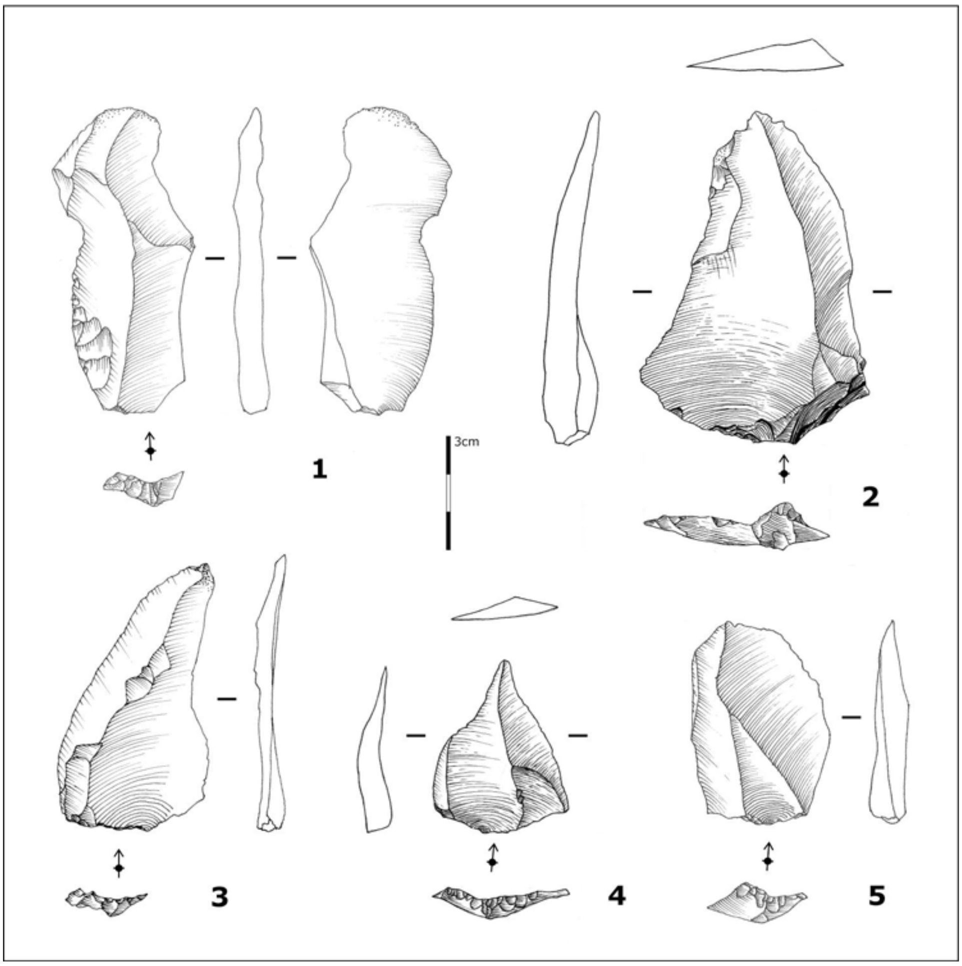


Fig.80: By-products of flaking surface preparation: 1, partially retouched by-product from recurrent unidirectional parallel method (level 5b3); 2-3, by-products from recurrent unidirectional convergent method (level 5b3); 4-5, by-products from local convexity maintenance (Nr.4: level 5b3; Nr.5: level 5AVI).

Fig.80

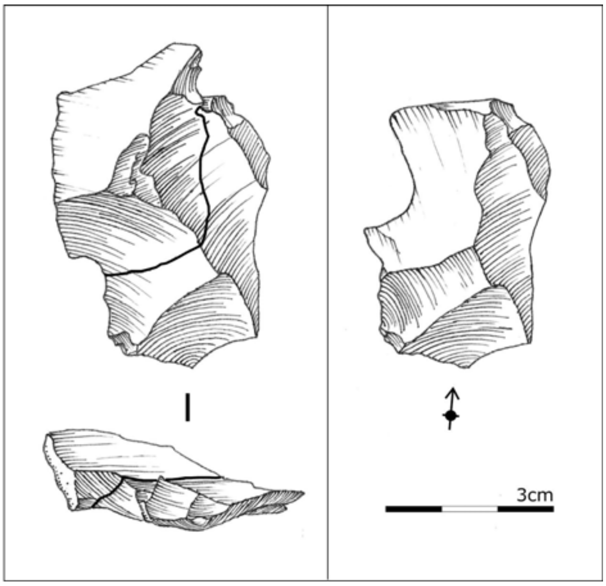


Fig.81: Small flaking surface flake with a cortical butt conjoining to a Levallois blank. The Levallois flake shows a centripetal scar pattern and was probably the initiating blank of a recurrent production phase during a late stage of core reduction. The core's distal convexity was probably insufficiently prepared because the Levallois fake exhibits a hinge fracture at its distal end.

Fig.81

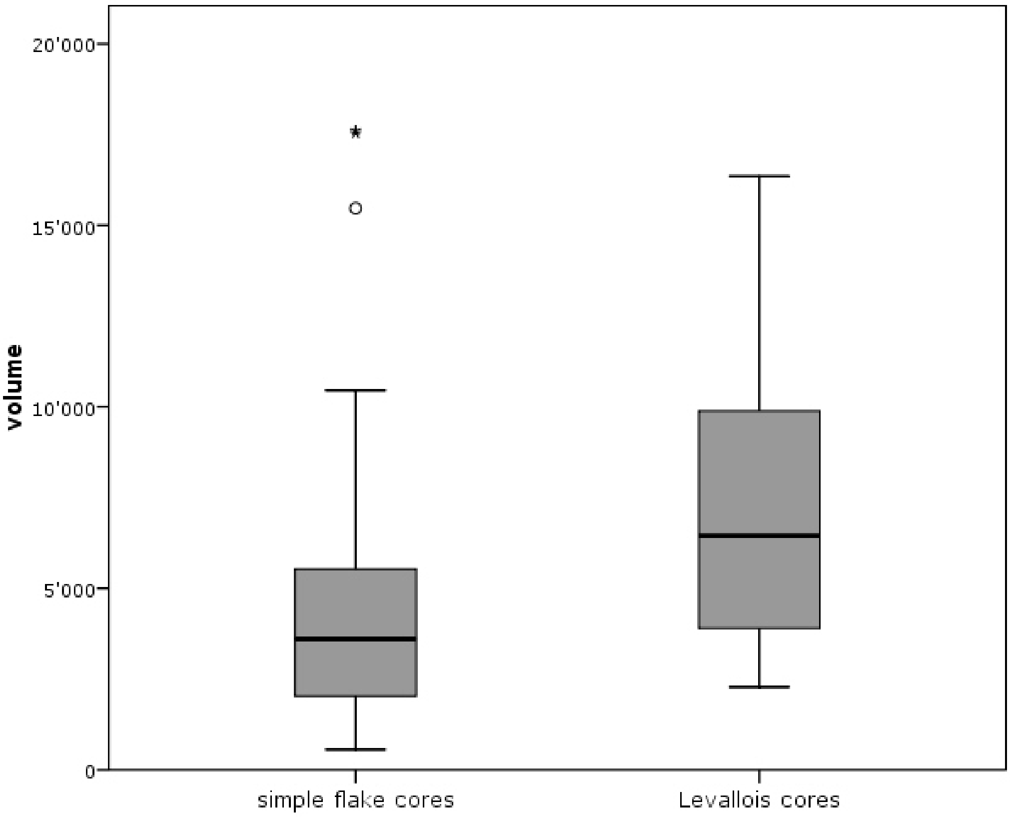


Fig.82: Boxplot showing the difference in volume between Levallois cores and simple flake cores. Volume is measured as length x width x thickness (in mm).

Fig.82

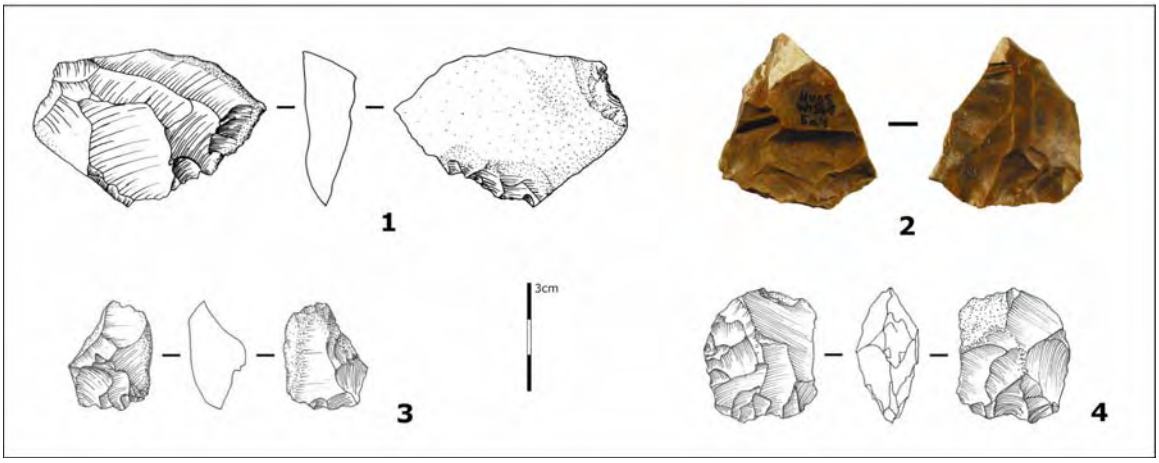


Fig.83: Examples of simple flake cores showing extensive exploitation before discard (Nr.1-3: level 5a4, Nr.4: level 5b2).

Fig.83

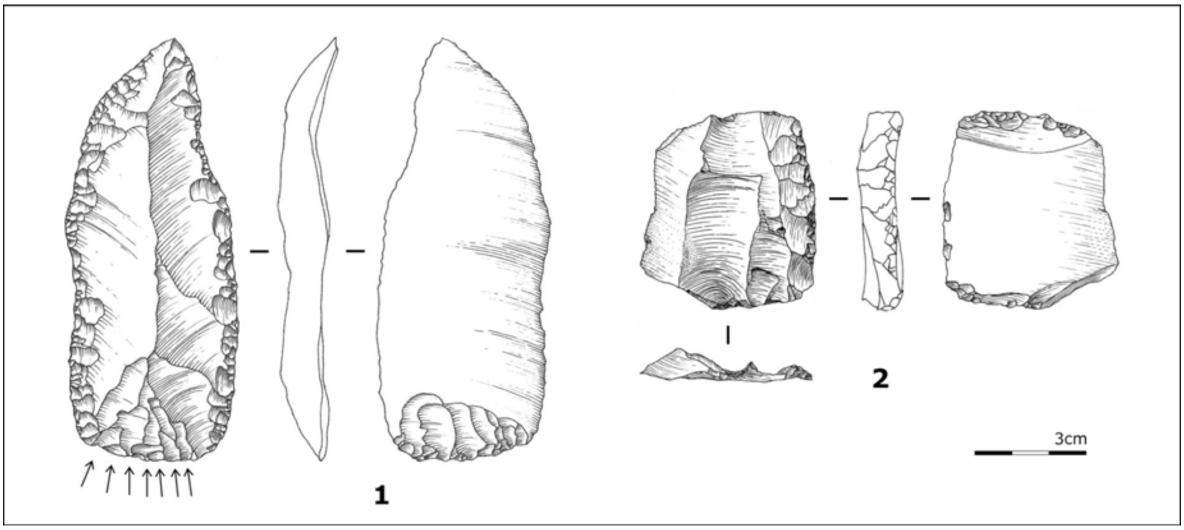


Fig.84: Two different functions of secondary flake removals: 1, double side scraper with a thinned base created for a hafting device (level 5b3); 2, core on flake made on broken simple side scraper (level 5e).

Fig.84

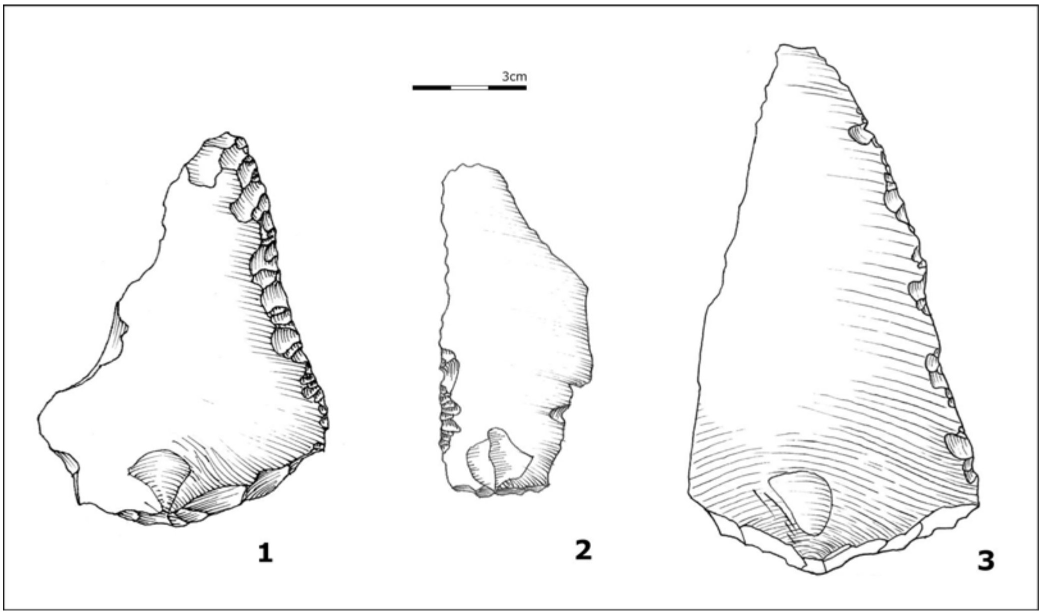


Fig.85: Examples of incidental Kombewa cores. Part of the bulbar region is either removed or small Kombewa-like flakes still adhere to the ventral surface (Nr.1-3: level 5b3).

Fig.85

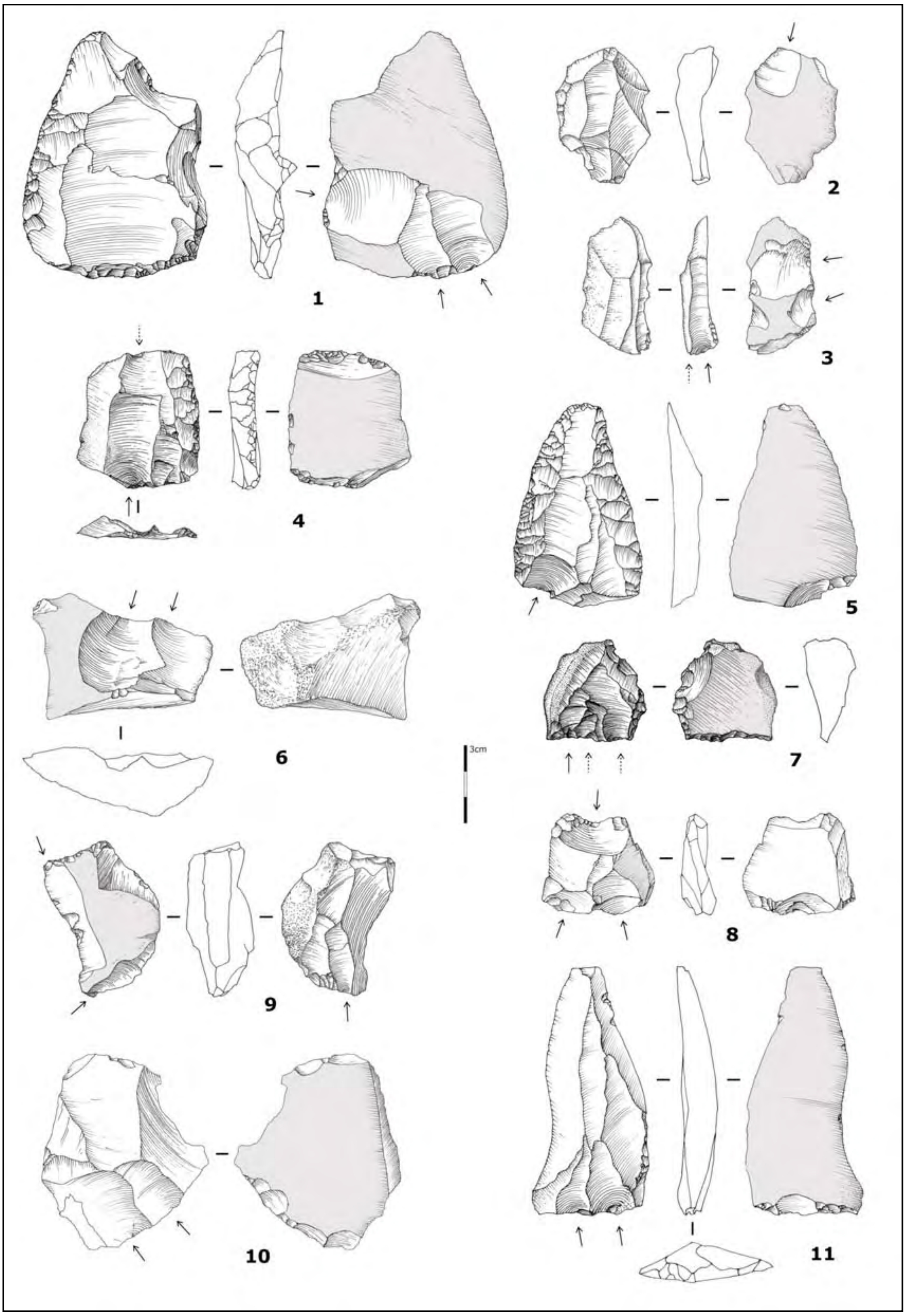


Fig.86: Selected examples of cores on flakes showing traces of secondary blank removals on the dorsal, ventral or both faces of flake blanks (Nr.1,5: level 5AIV; Nr.2-3,10: level 5b5; Nr.4: level 5e; Nr.6: level 5AII; Nr.7: level 5a3; Nr.8: level 5E; Nr.9,11: level 5AVI).

Fig.86

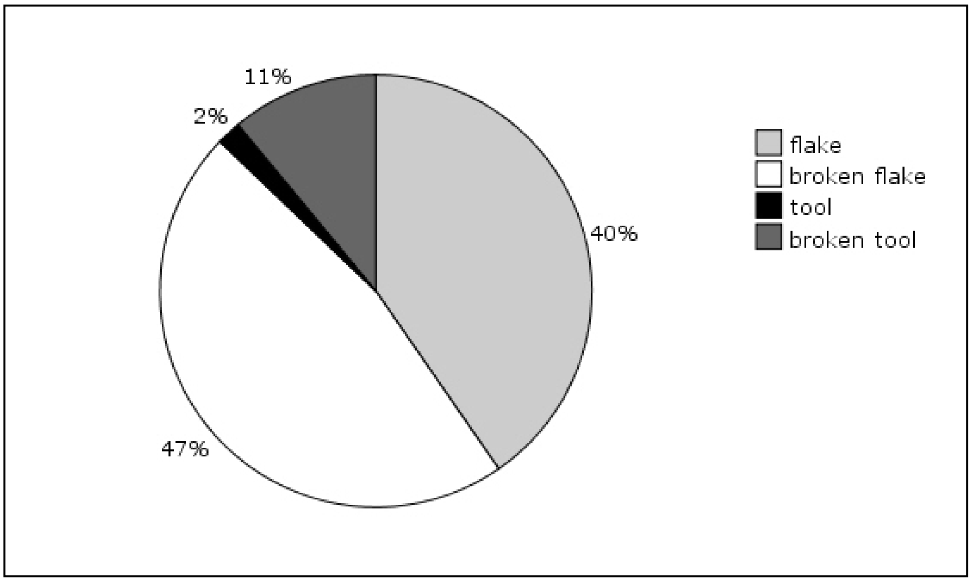


Fig.87: Frequency of blank types which were recycled for a secondary blank production.

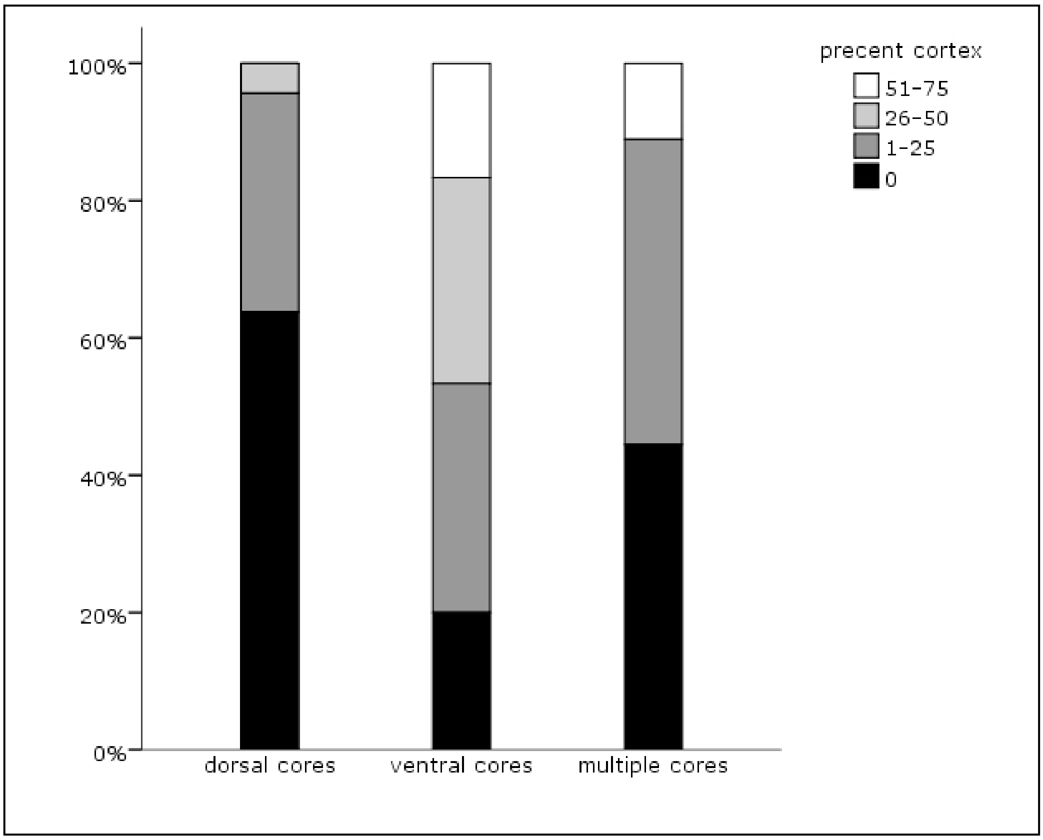


Fig.88: The amount of cortex in each core on flake category.

Fig.88

Fig.89

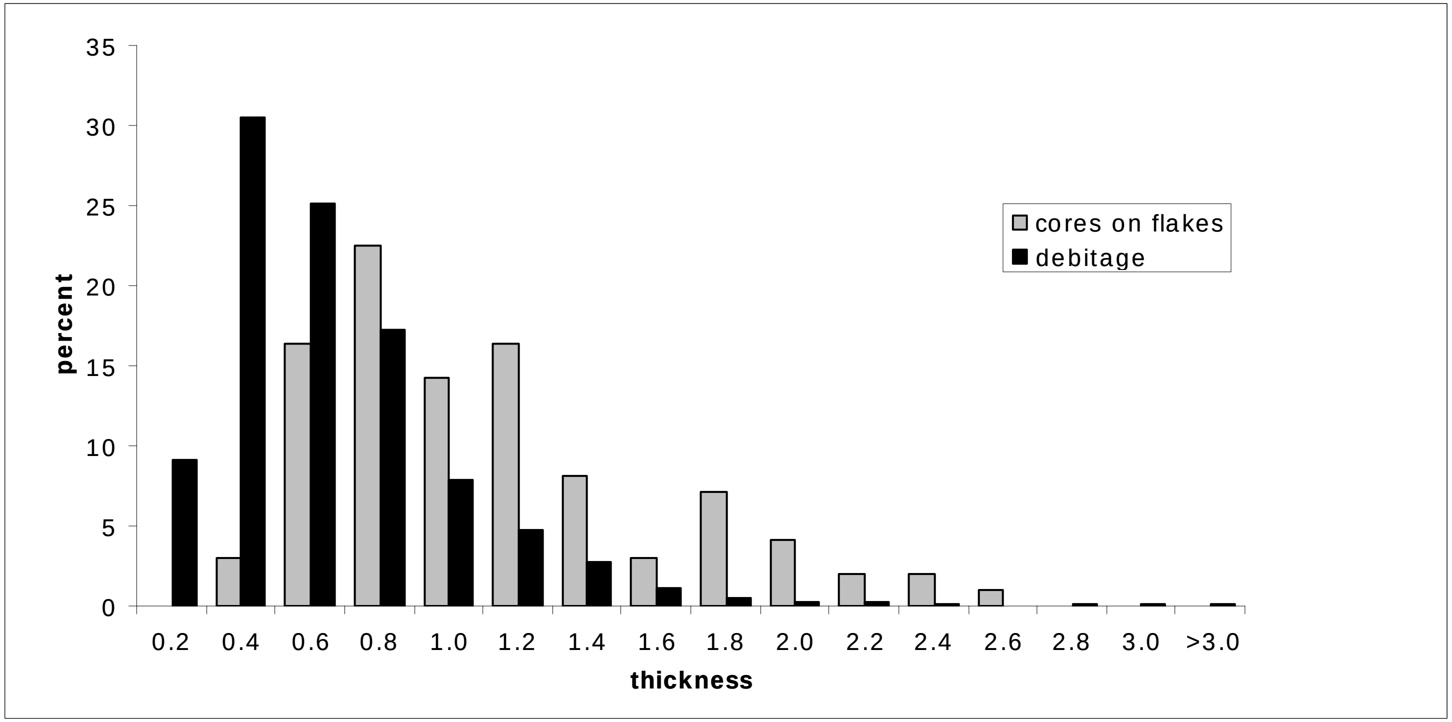


Fig.89: Distribution of thickness values of cores on flakes compared to the total sample of flaked artifacts.

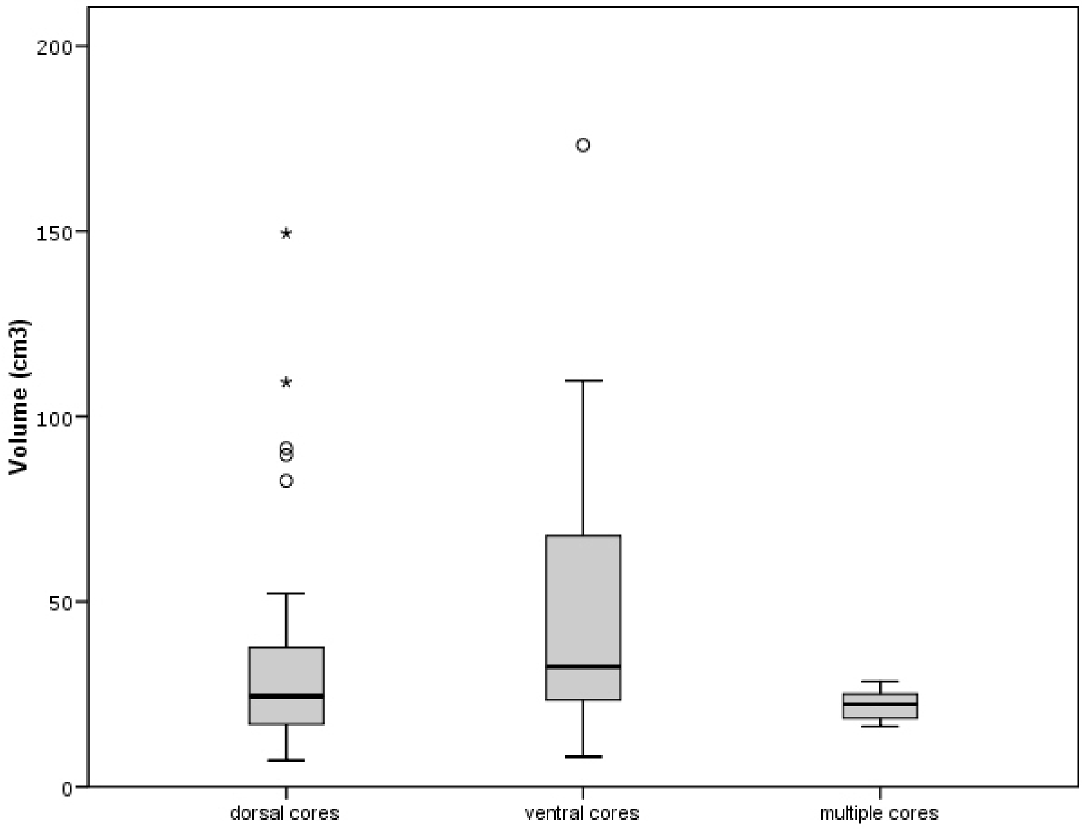
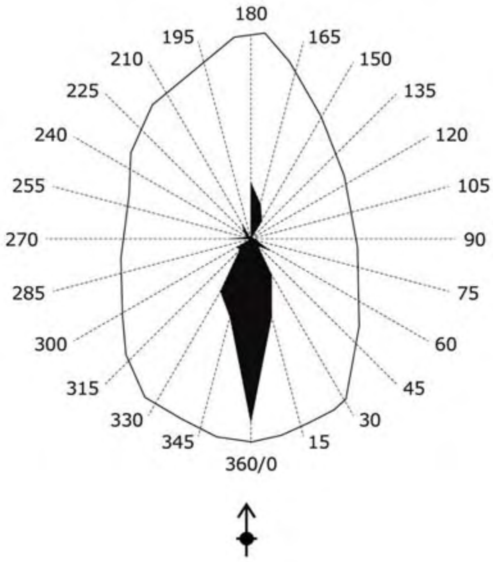


Fig.90: Comparison between core on flake categories in respect to core volume (measured as length x width x thickness).



inclination range	N	%
360/0 -14	40	27.4
15 - 29	16	11.0
30 - 44	8	5.5
45 - 59	2	1.4
60 - 74	4	2.7
75 - 89	1	0.7
90 - 104	1	0.7
105 - 119	1	0.7
120 - 134	0	0.0
135 - 149	0	0.0
150 - 164	4	2.7
165 - 179	7	4.8
180 - 194	11	7.5
195 - 209	0	0.0
210 - 224	3	2.1
225 - 239	2	1.4
240 - 254	2	1.4
255 - 269	1	0.7
270 - 284	6	4.1
285 - 299	0	0.0
300 - 314	5	3.4
315 - 329	3	2.1
330 - 344	12	8.2
345 - 359	17	11.6

Fig.91: Analysis of flaking directions on cores on flakes. The diagram to the right shows the frequency distribution of inclinations measured for secondary negatives in relation to the flaking axis of the blank. Corresponding values are given in the table to the right.

Fig.91

Fig.92

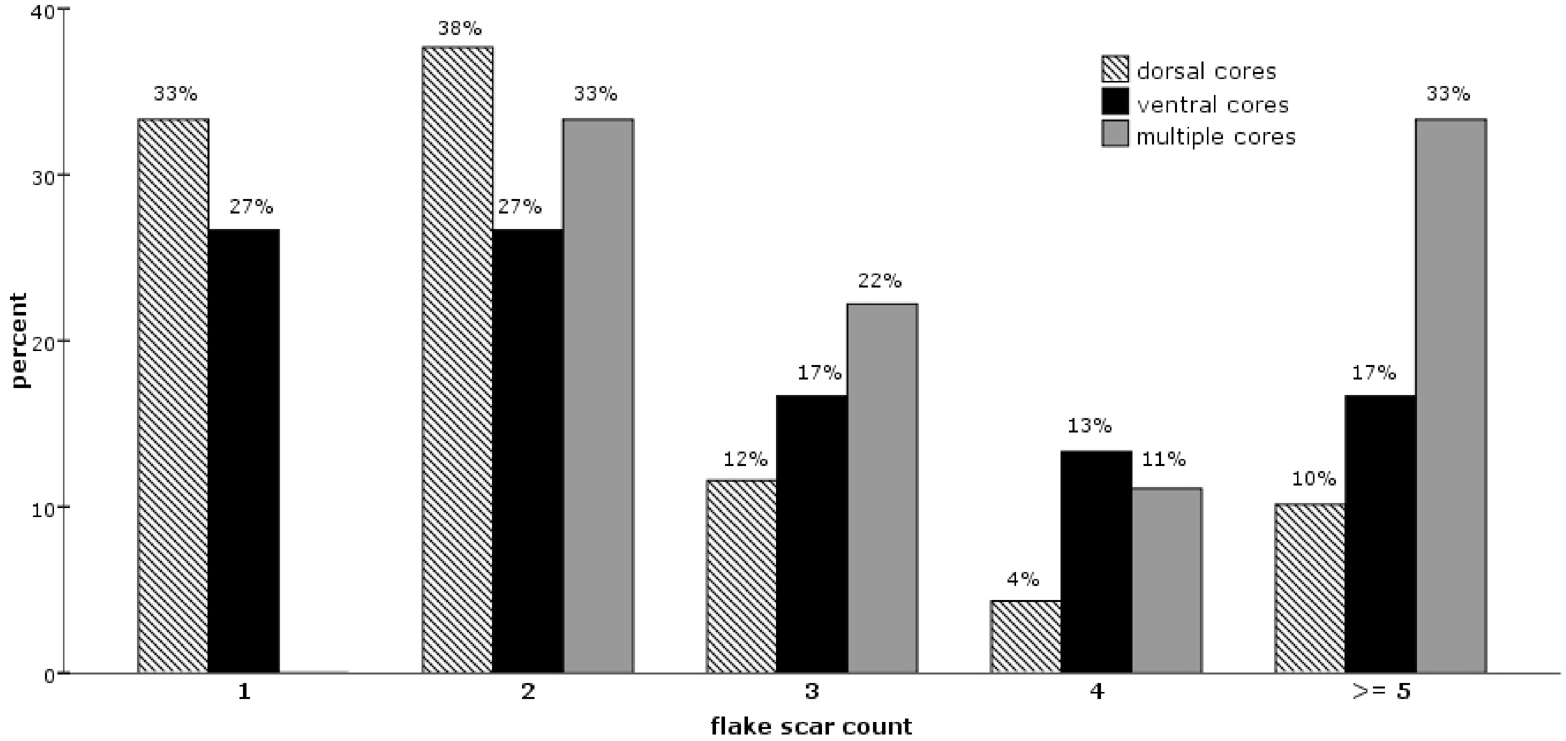


Fig.92: Difference of reduction intensity between core on flake types determined by the number of secondary flake scars.

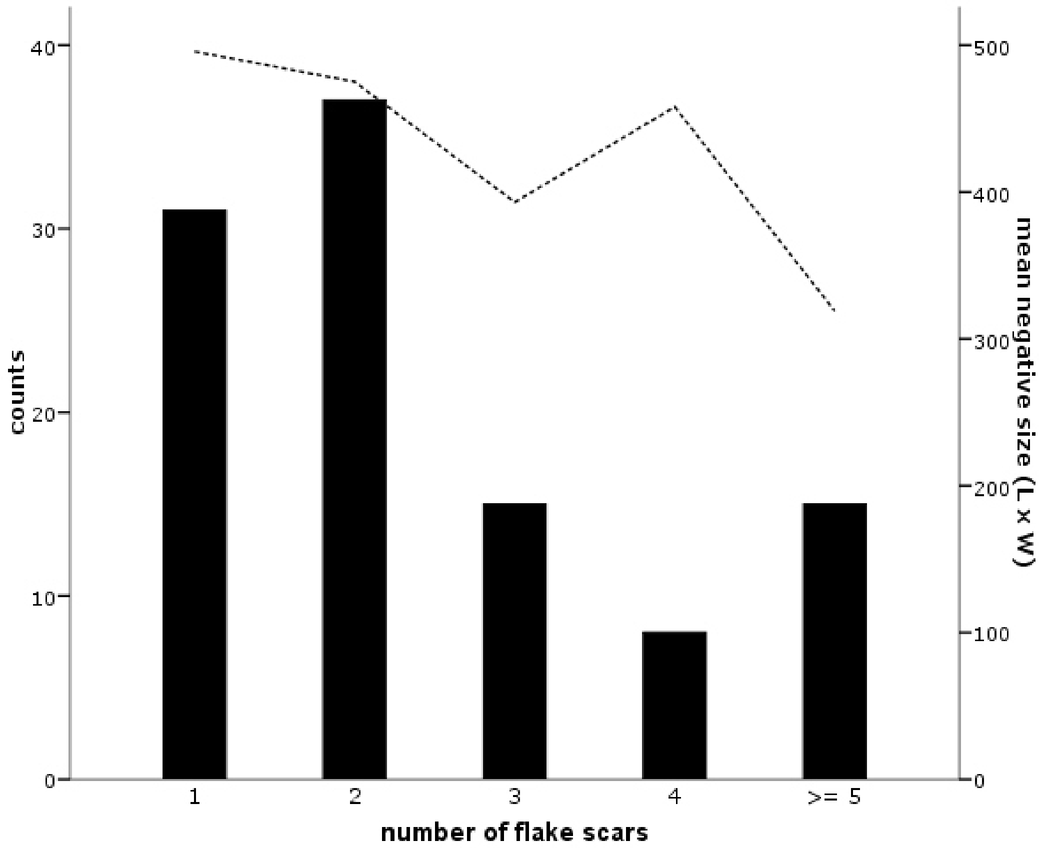


Fig.93: Relationship between the number of secondary flake scars on cores on flakes and the size of secondary flake blanks.

Fig.93

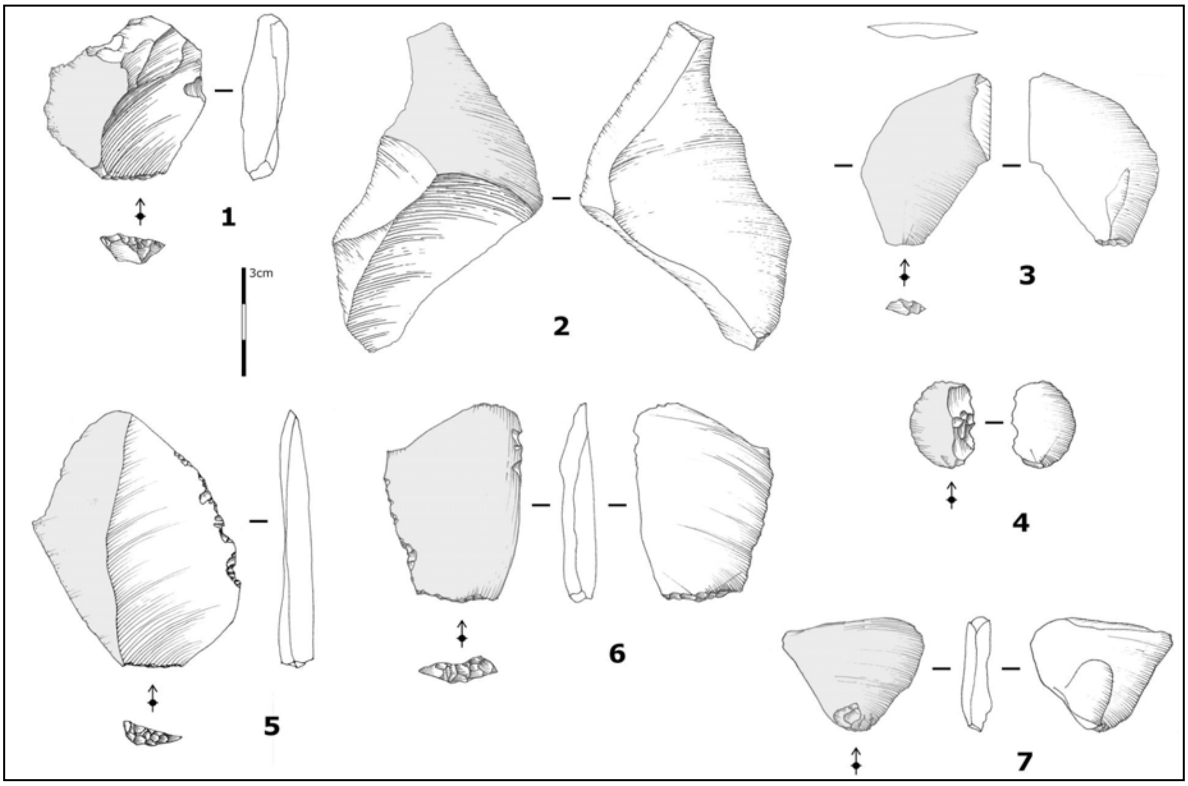


Fig.94: Selected Kombewa and Janus flakes. The ventral surface of the flake blank is indicated in grey color. Nr.1: Janus flake (level 5b5), Nr.2: Janus flake stemming from Levallois point production (level 5b5), Nr.3: Kombewa flake (level 5b3), Nr.4: retouched Kombewa flake (level 5b7), Nr.5: Janus flake showing use wear on the right edge (level 5E), Nr.6: Kombewa flake showing use wear on both edges (level 5b5), Nr.7: Kombewa flake (level 5AIV).

Fig.94

Fig.95: Two limestone flakes (Nr.1: level 5b1, Nr.2: level 5b5) and one simple flake core made of limestone (level 5b1).

Fig.95

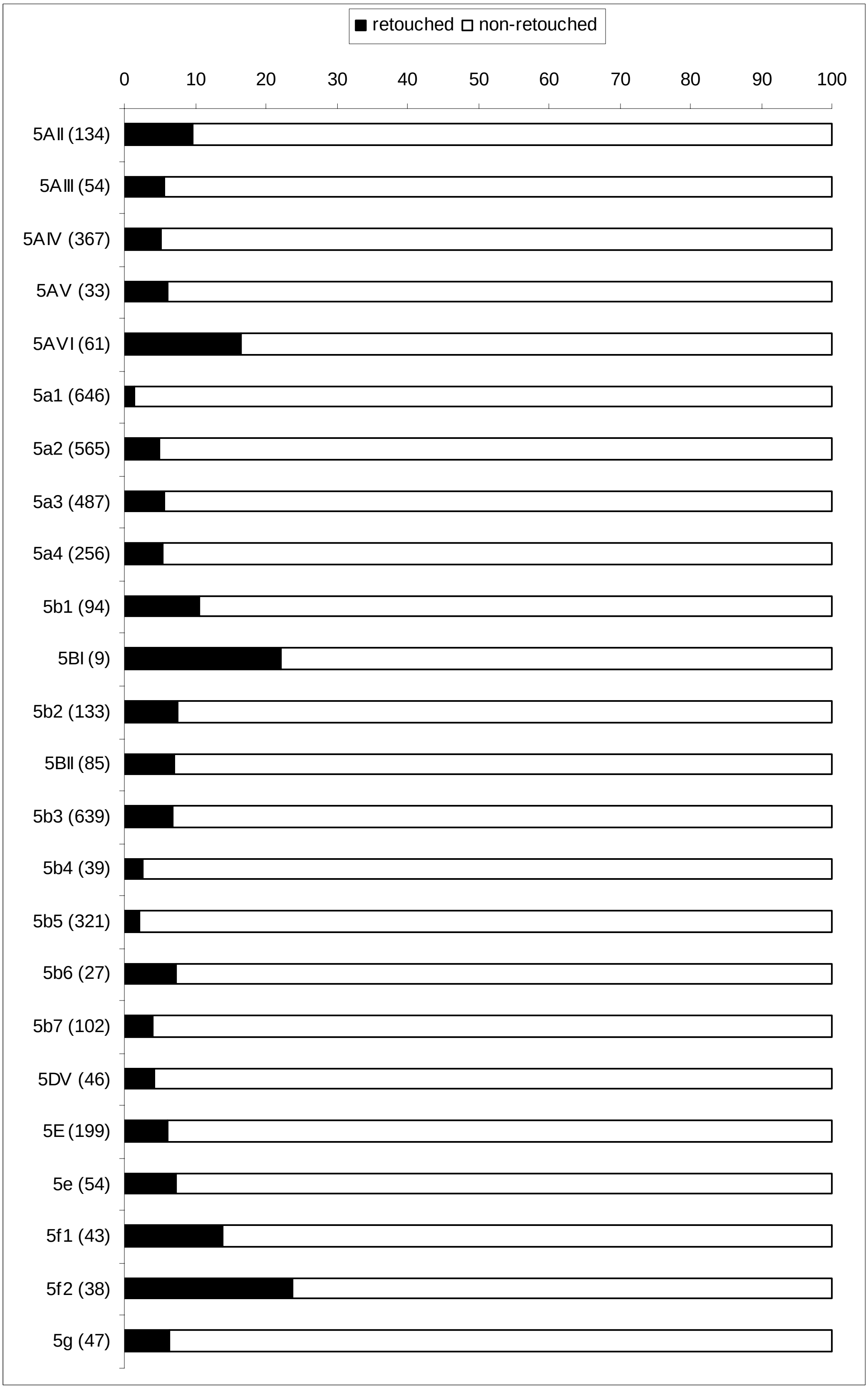


Fig.96: Percentage of retouched tools in Mousterian levels of Hummal.

Fig.96

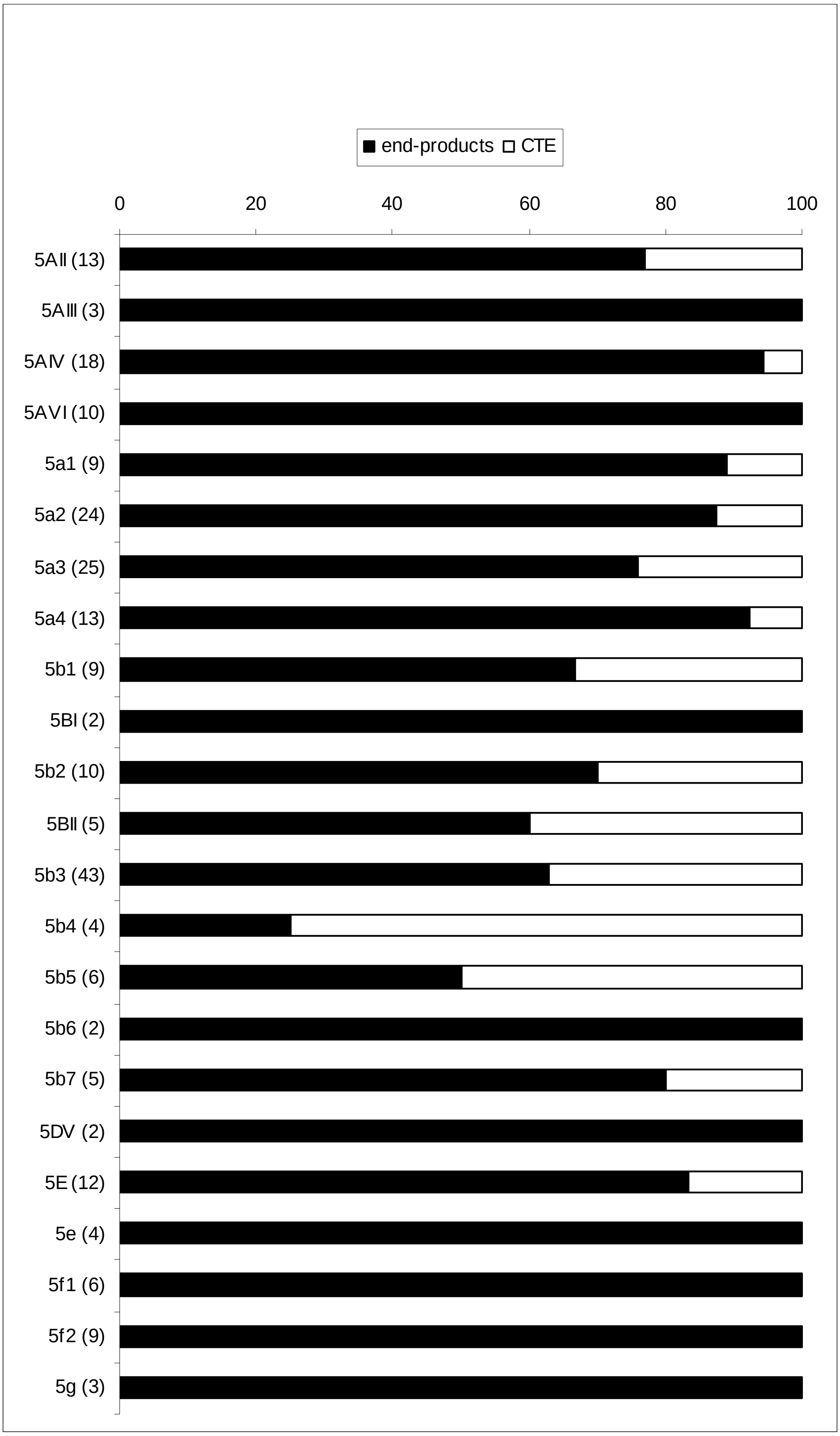


Fig.97: Percentage of end-products and core trimming elements (CTE) among the group of retouched tools in the Mousterian levels of Hummal.

Fig.97

Fig.98

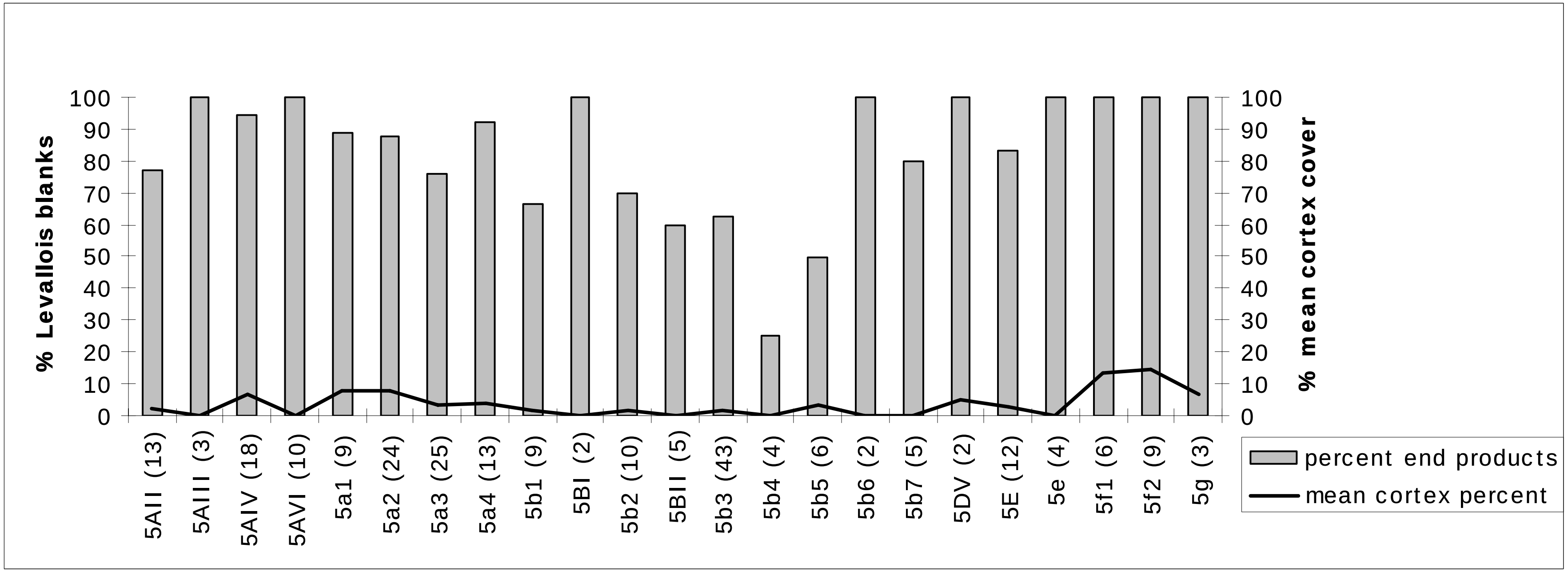


Fig.98: Percentage of Levallois blanks and mean percentage of cortex cover on Levallois blanks among the group of retouched tools in the Mousterian levels of Hummal.

Fig.99

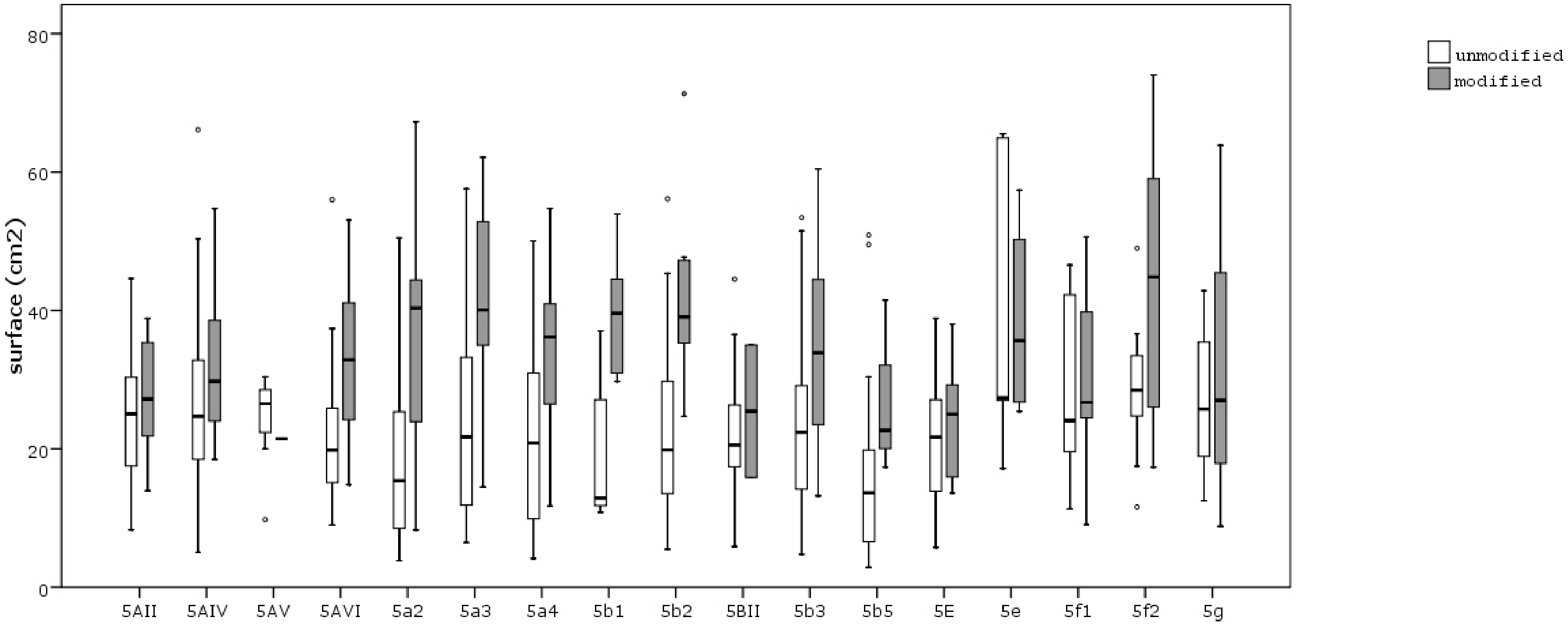


Fig.99: Difference between the size range of retouched and unretouched flakes in selected Mousterian levels of Hummal.

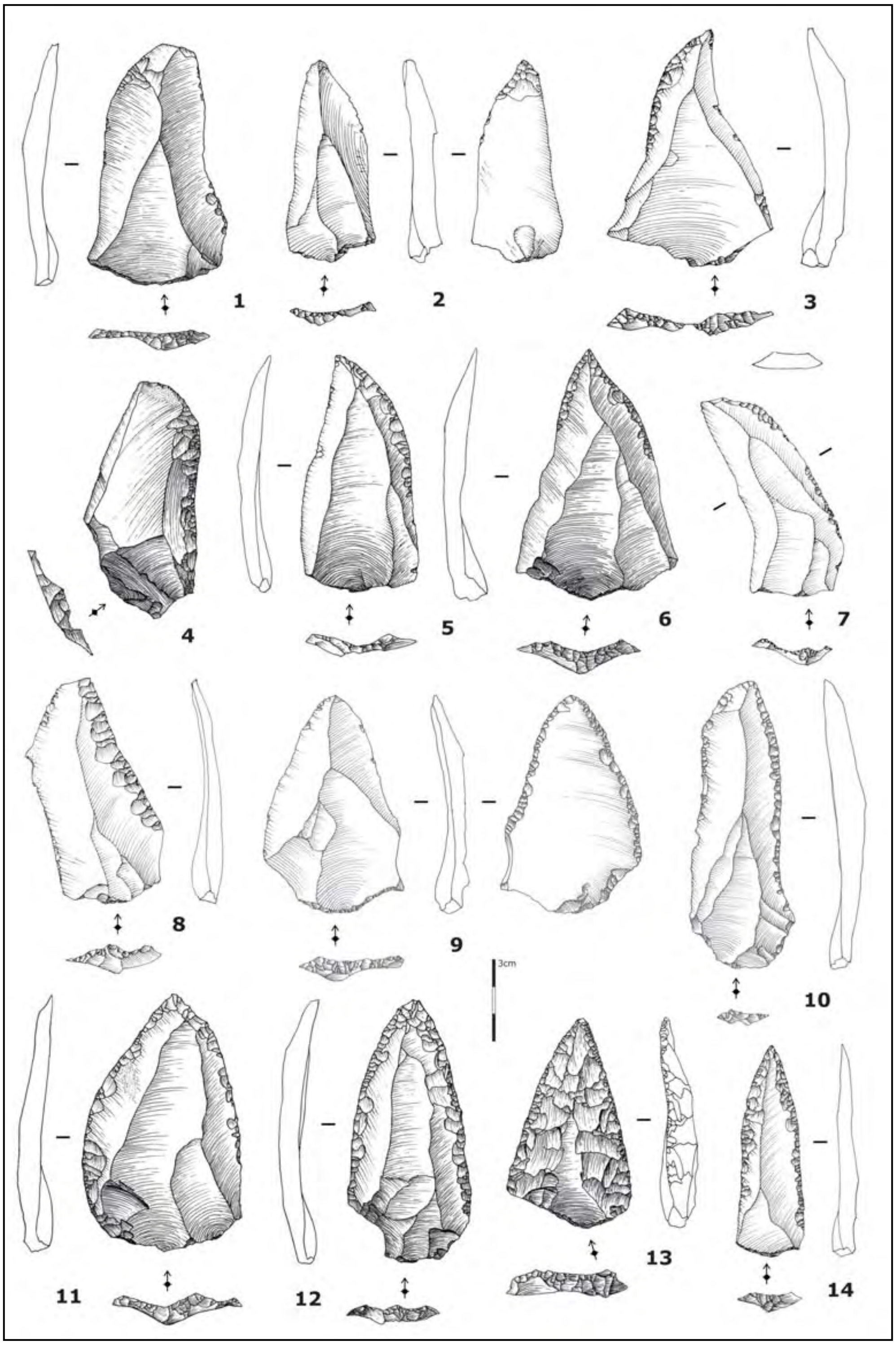


Fig.100: Examples of partially retouched blanks and scrapers: Nr.1-2, 7, partially retouched Levallois points (Nr.1: level 5a4; Nr.2: level 5AIV; Nr.7: level 5a3); Nr. 3-5, 8, single side scraper types (Nr.3: level 5AIV; Nr.4,8: level 5a4; Nr.5: level 5a3); Nr. 6, 8-12, double side scraper types (Nr.6: level 5a4; Nr.9: level 5AIII; Nr.10: level 5DV; Nr.11, 12: level 5b1); Nr. 13-14: Mousterian points (Nr. 13: level 5b2; Nr.14: level 5E).

Fig.100

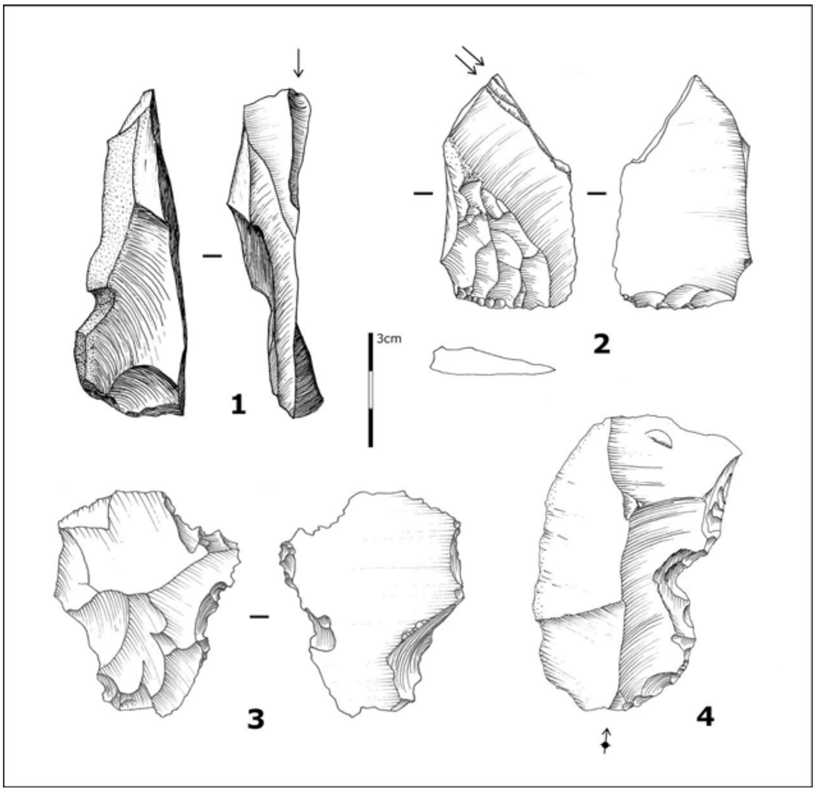


Fig.101: Examples of burins, denticulates and notched pieces. Nr.1-2, typical burins (Nr.1: level 5b2; Nr.2: level 5b7); Nr.3, denticulate (level 5b5); Nr.4: notched piece (level 5b3).

Fig.101

Fig.102

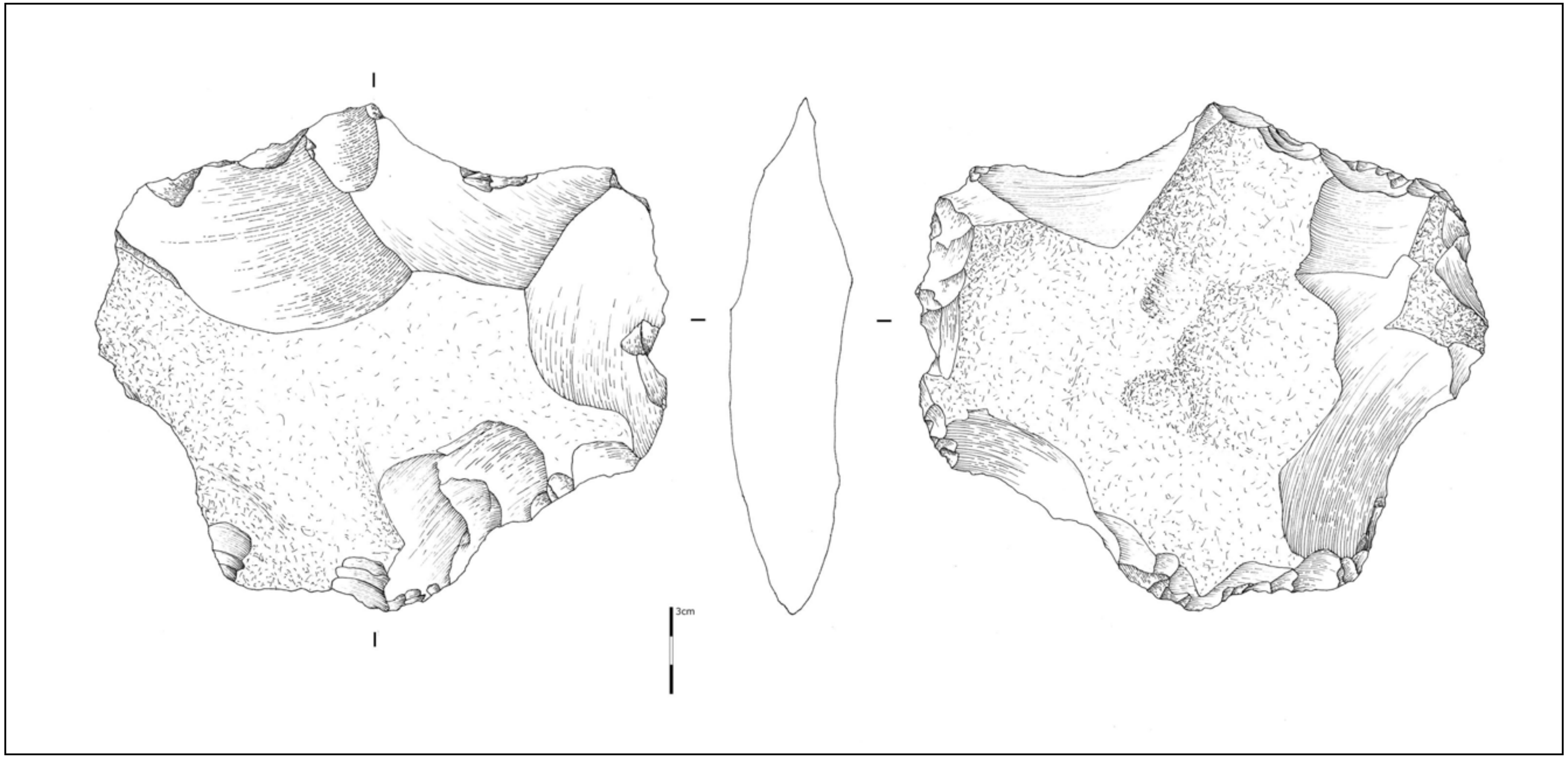


Fig.102: Large chopping tool made on a limestone slab (level 5b1).

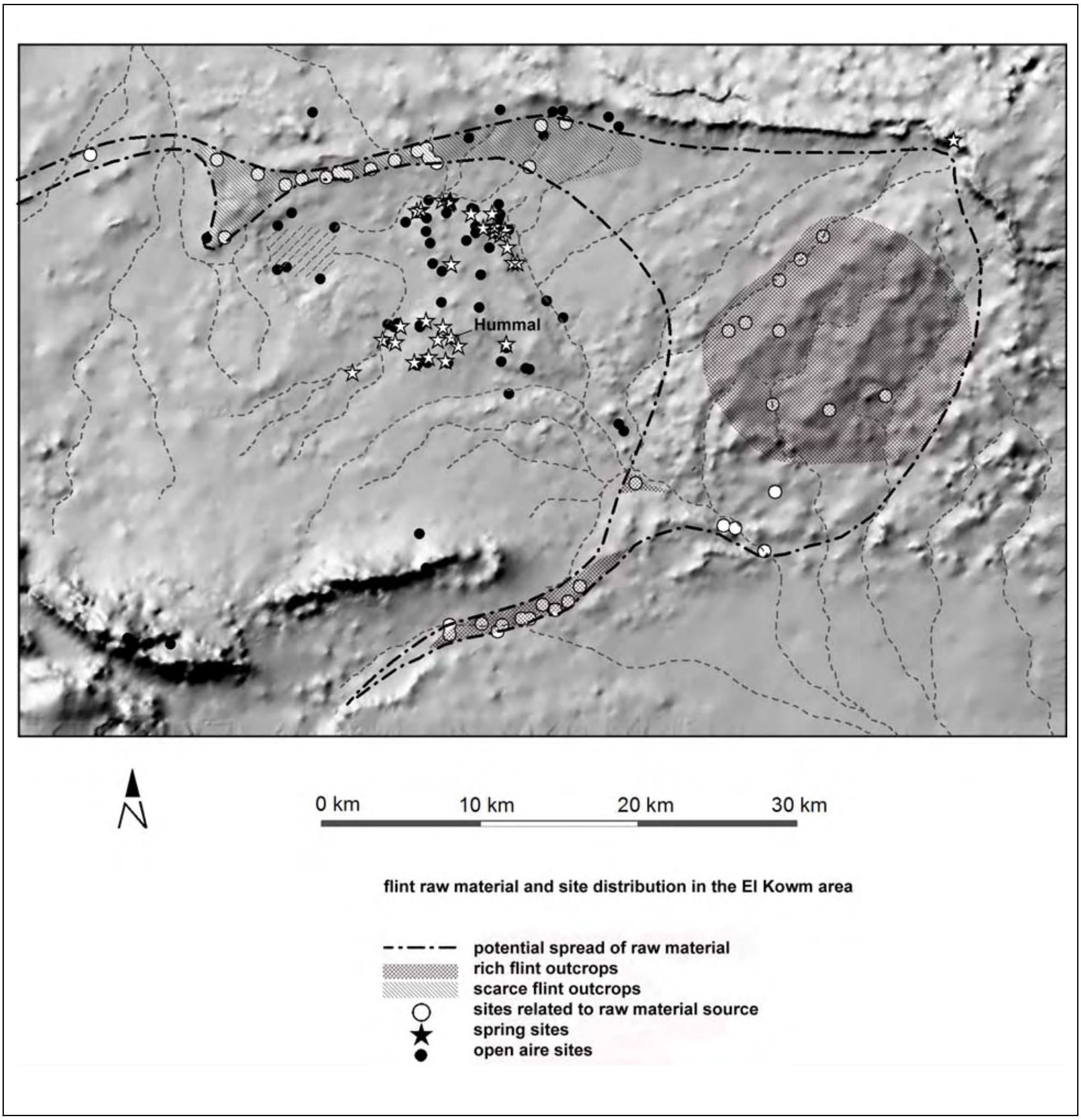


Fig.103: Map of the El Kowm region showing the location of flint outcrops and distribution of different Paleolithic site-types (after Le Tensorer & Jagher 2001, Fig.6).

Fig.103

Fig.104: Vein with large-sized flint nodules weathering out on a foothill of the Bishri escarpment.

Fig.104

Fig.105: Angular slabs of Cretaceous flint weathering out at the base of the Jebel Mqebra escarpment.

Fig.105

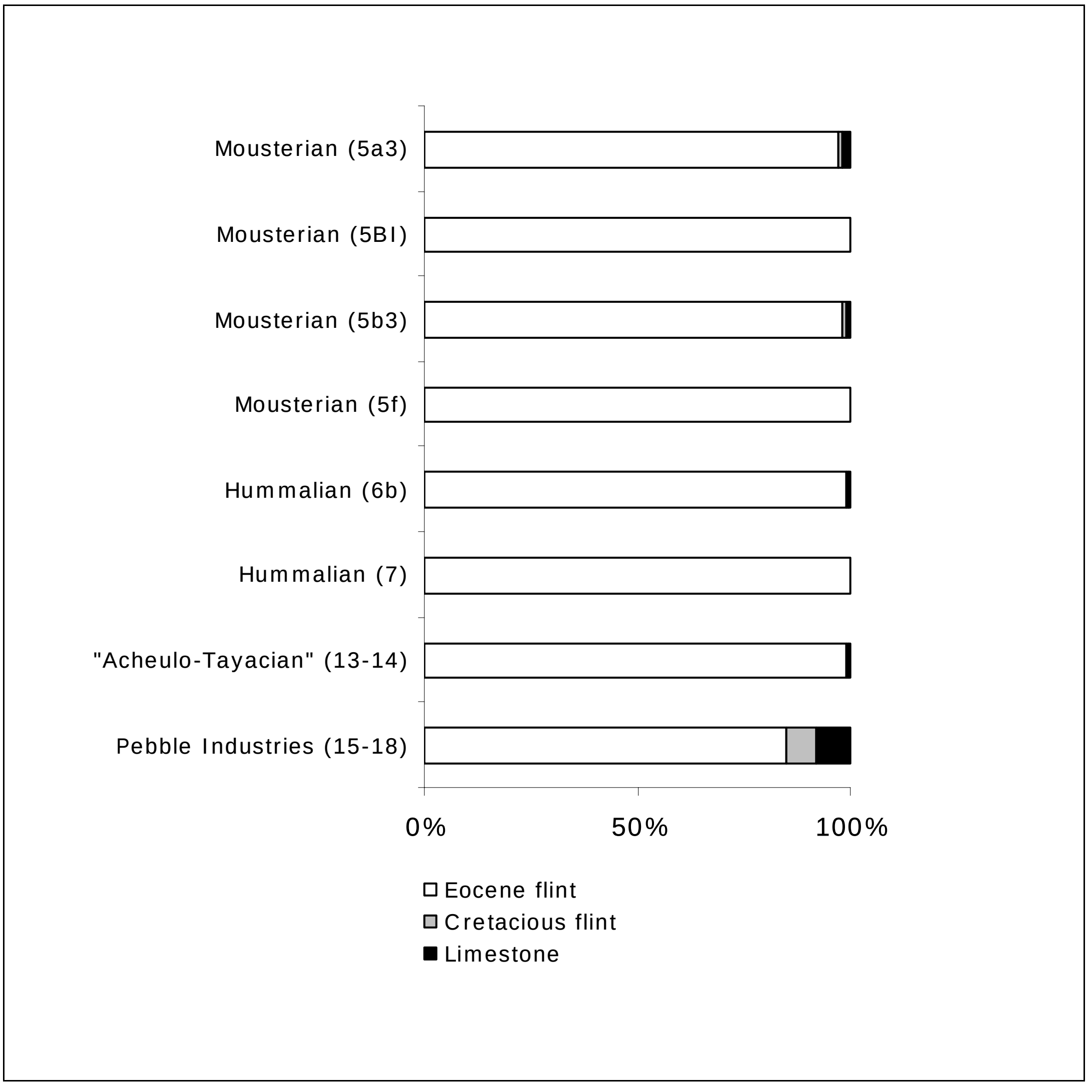


Fig.106: Frequency distribution of major raw material types in selected levels of the Hummal sequence.

Fig.106

Fig.107: Dense scatter of core reduction debris found at a work shop site located at the foothills of the northern Bishri escarpment.

Fig.107

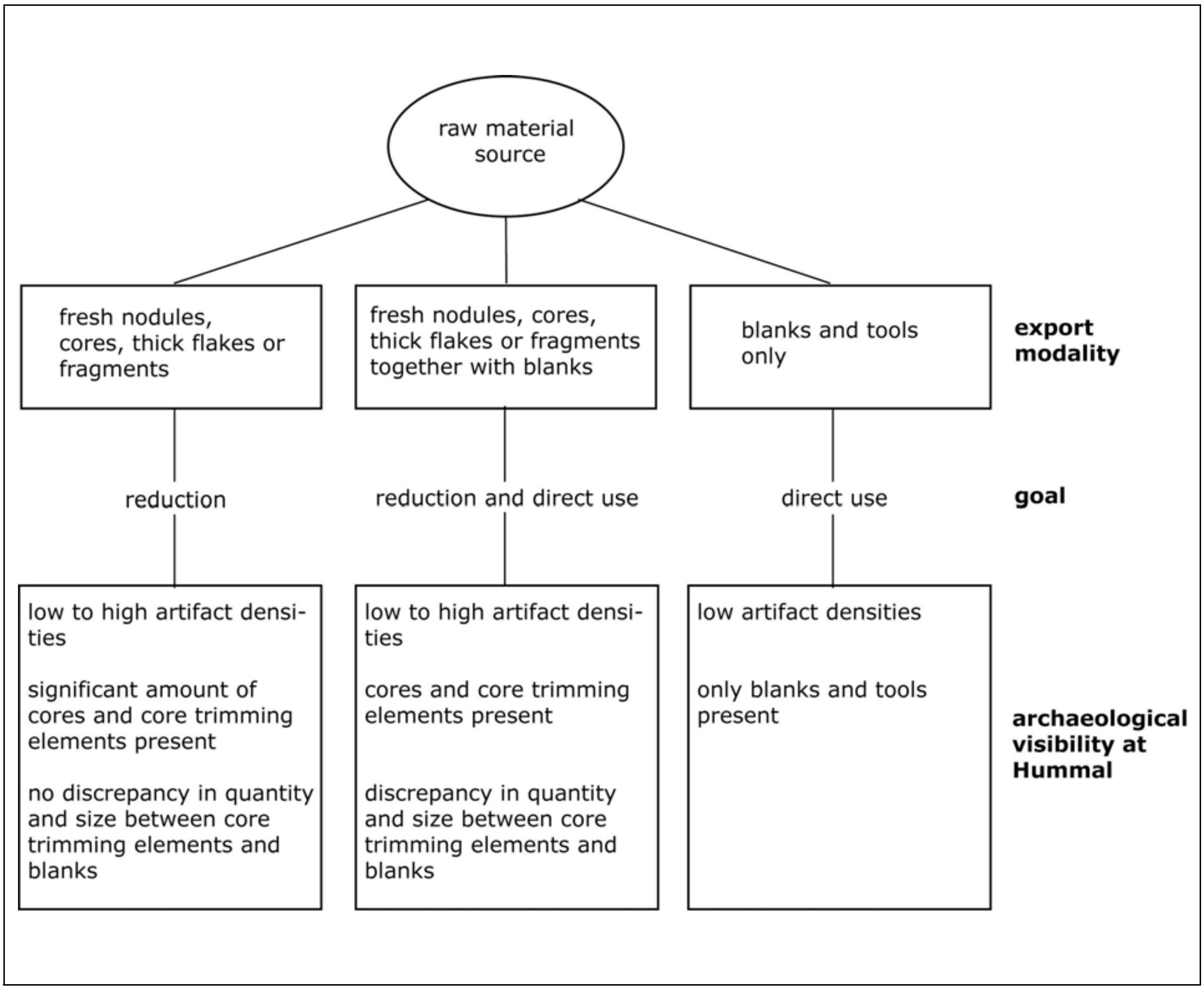


Fig.108: Possible raw material provisioning strategies and their archaeological visibility.

Fig.108

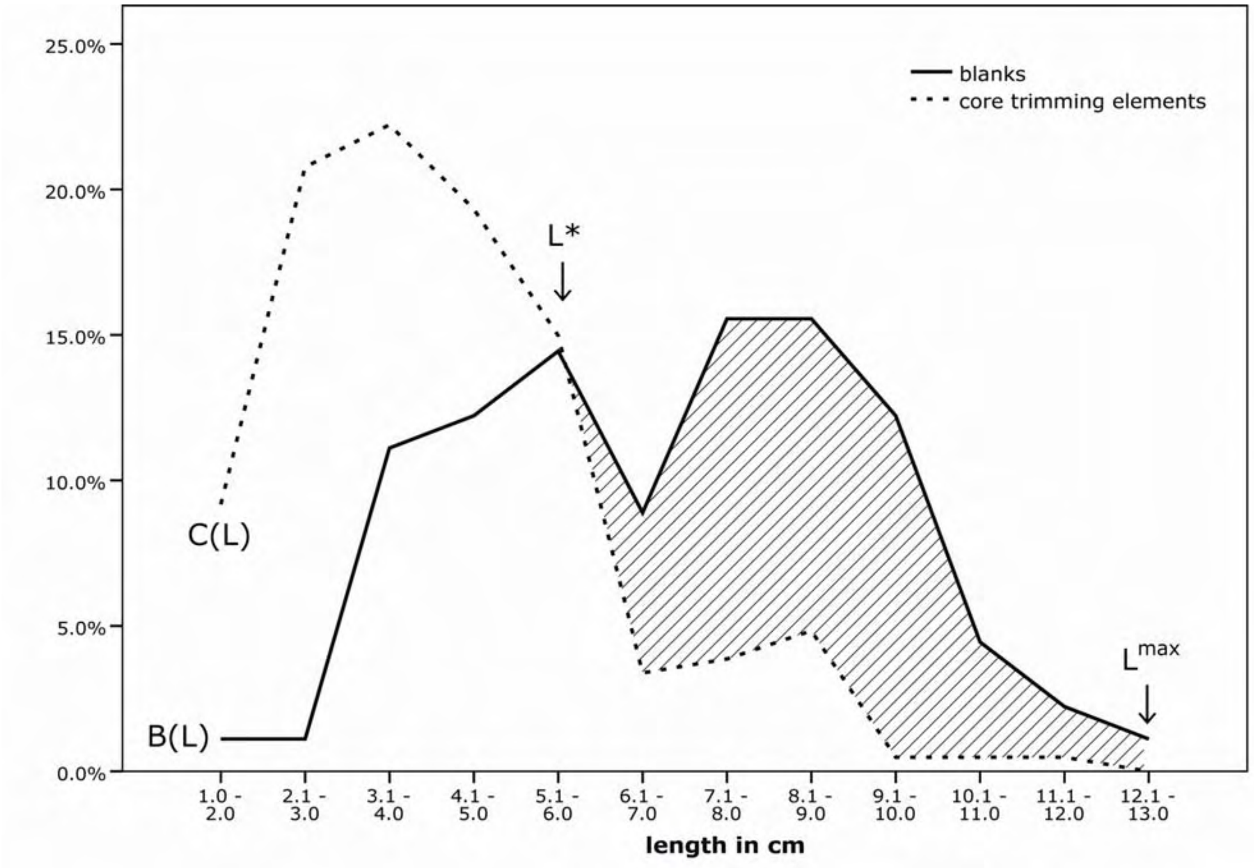


Fig.109: Size distribution of core trimming elements (C) and blanks (B) in assemblage 5a3. L* marks the point of intersection between both curves in the upper size range. L^{max} indicates the maximum length measured. The area between both curves in the upper size range is shaded.

Fig.109

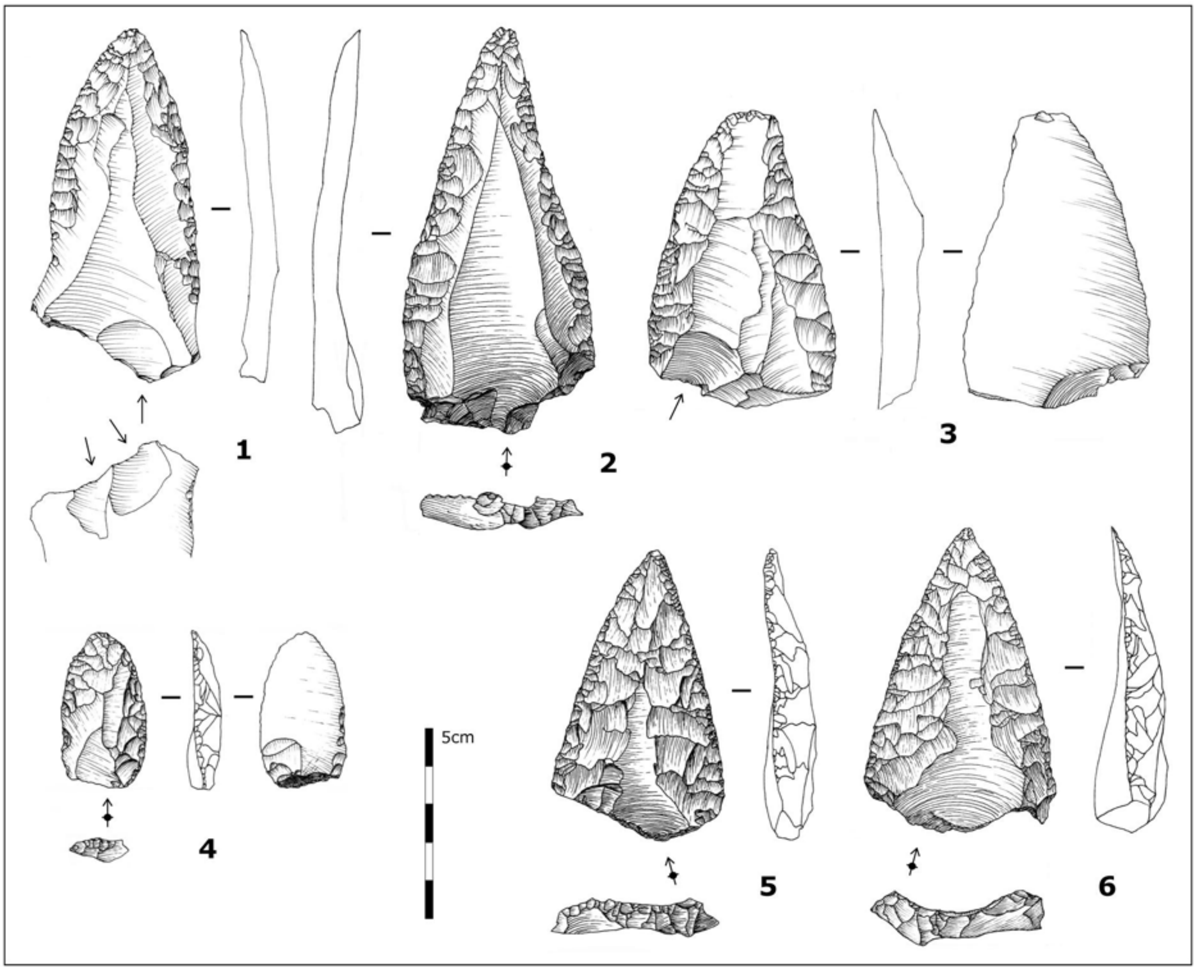


Fig.110: Selected curated tools: Nr.1: double edge scraper with secondary flake removals on proximal end (level 5a4), Nr.2: Mousterian point (level 5a3), Nr.3: double side scraper with secondary flake removal on proximal end (level 5AIV); Nr.4: double side scraper (level 5f1); Nr.5-6: Mousterian points (level 5b2).

Fig.110

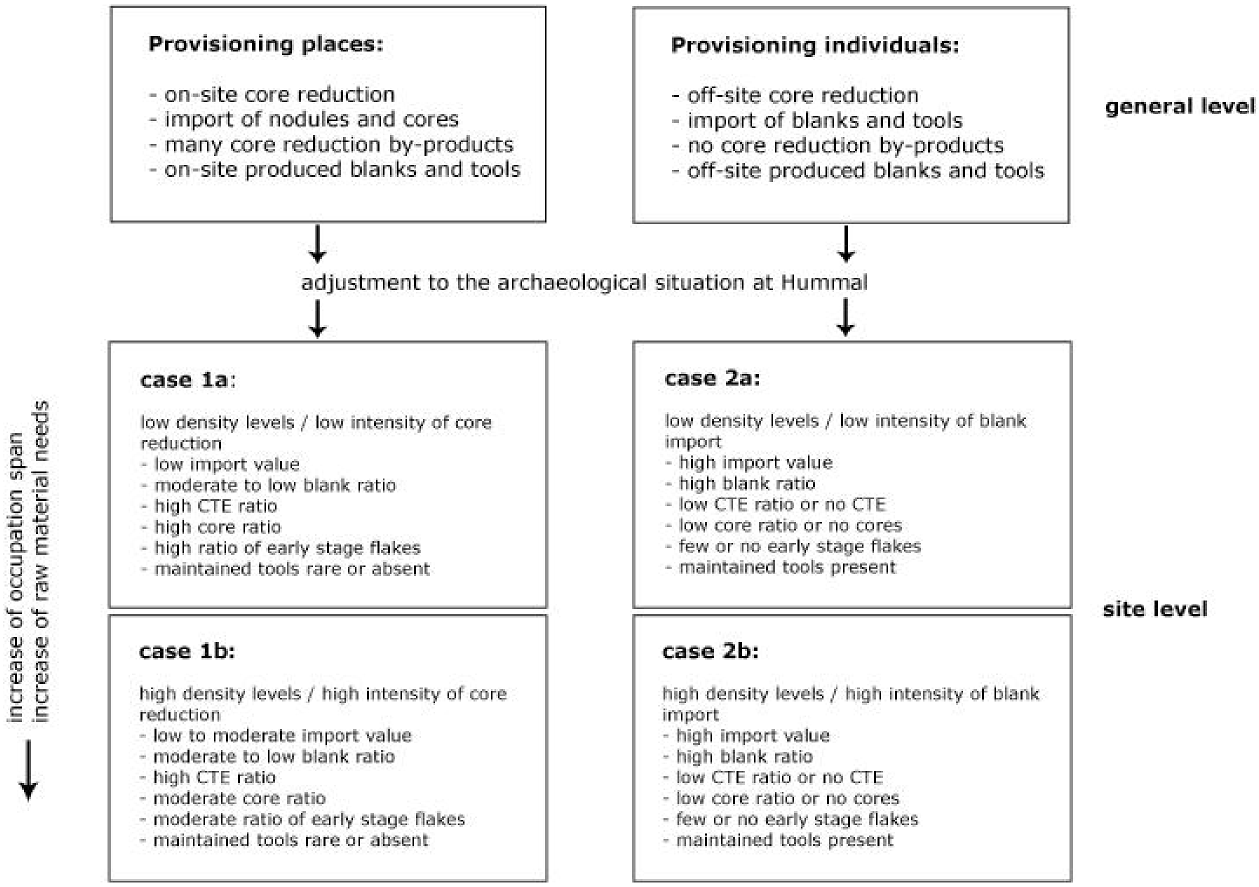


Fig.111: Model of the lithic organization according to the provisioning of places vs. provisioning of individuals strategy. Reflecting both strategies, cases 1a, 1b, 2a, and 2b represent the expected assemblage structures. Sub-cases are differentiated on the basis of occupation length and corresponding difference in raw material consumption.

Fig.111

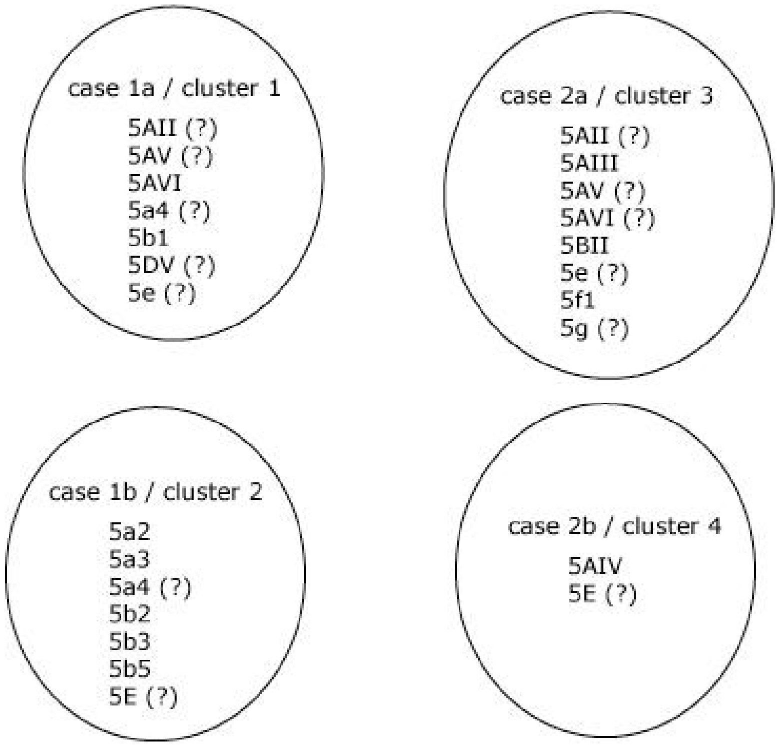


Fig.112: Expect clustering of Mousterian assemblages according to the case allocation in Table 52.

Fig.112

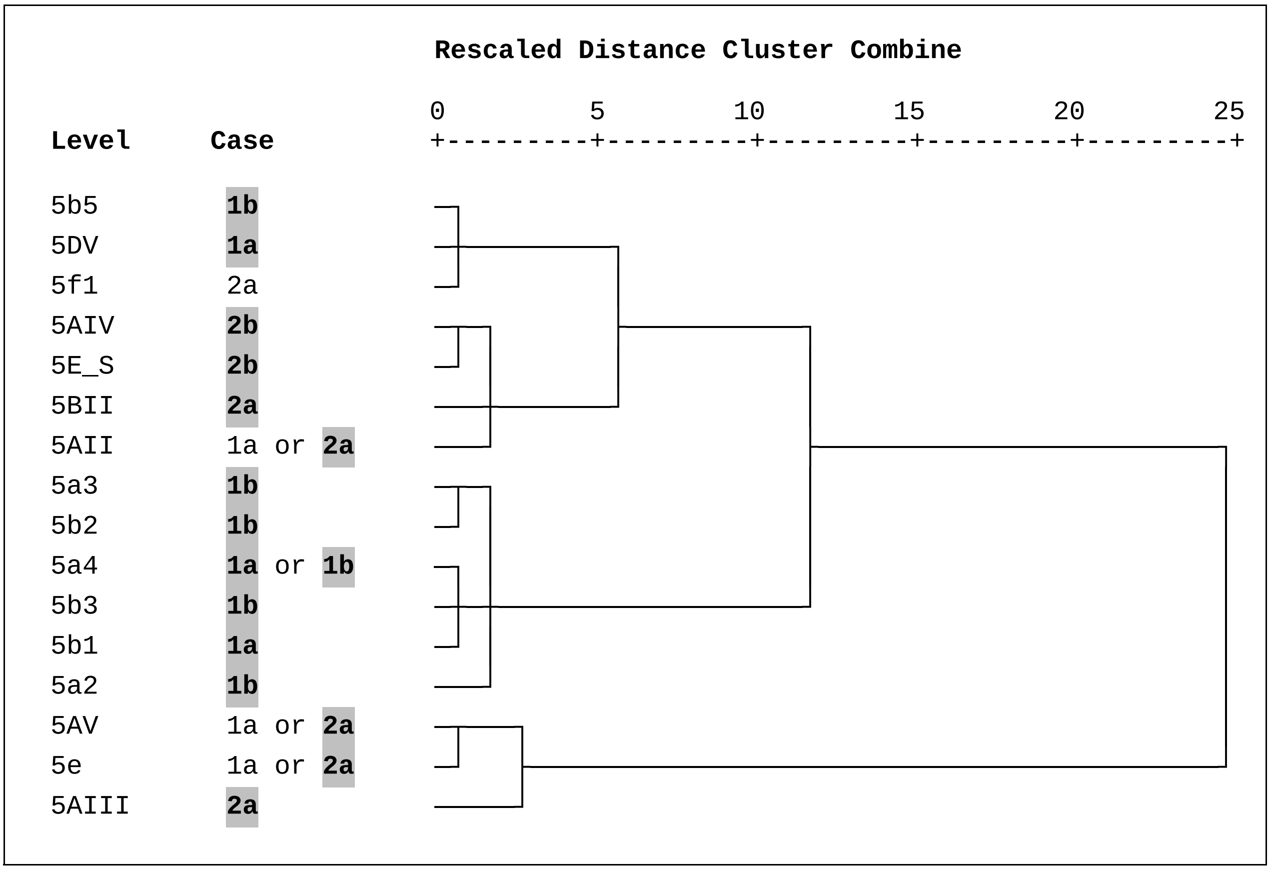


Fig.113: Result of a cluster analysis using the Ward method. Meaningful or expected case allocations are highlighted in grey color.

Fig.113

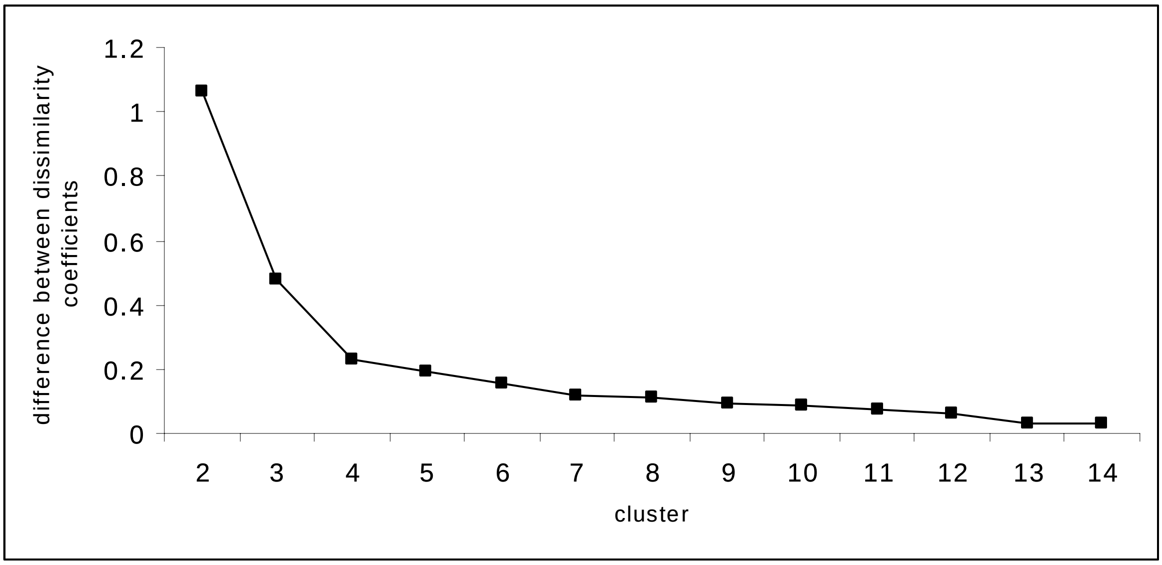


Fig.114: Plot of the difference between dissimilarity coefficients for the range of possible clusters. The curve's marked bend between the third and fifth cluster indicates that a clustering in four groups most appropriately reflects the data structure.

Fig.114

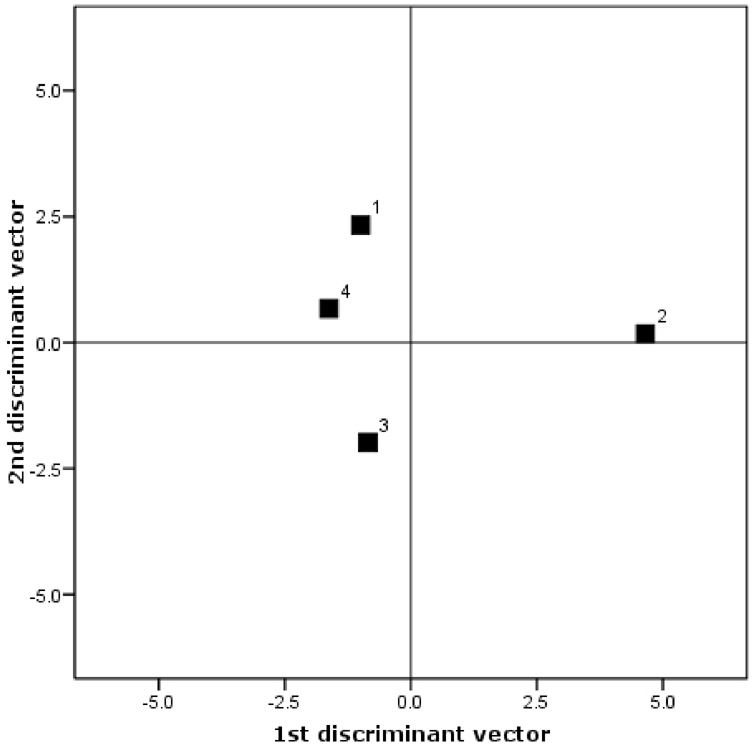


Fig.115: Plot of first two discriminant vectors for each cluster according to the data shown in Table 53. The plot graphically illustrates the distance between the groupings.

Fig.115

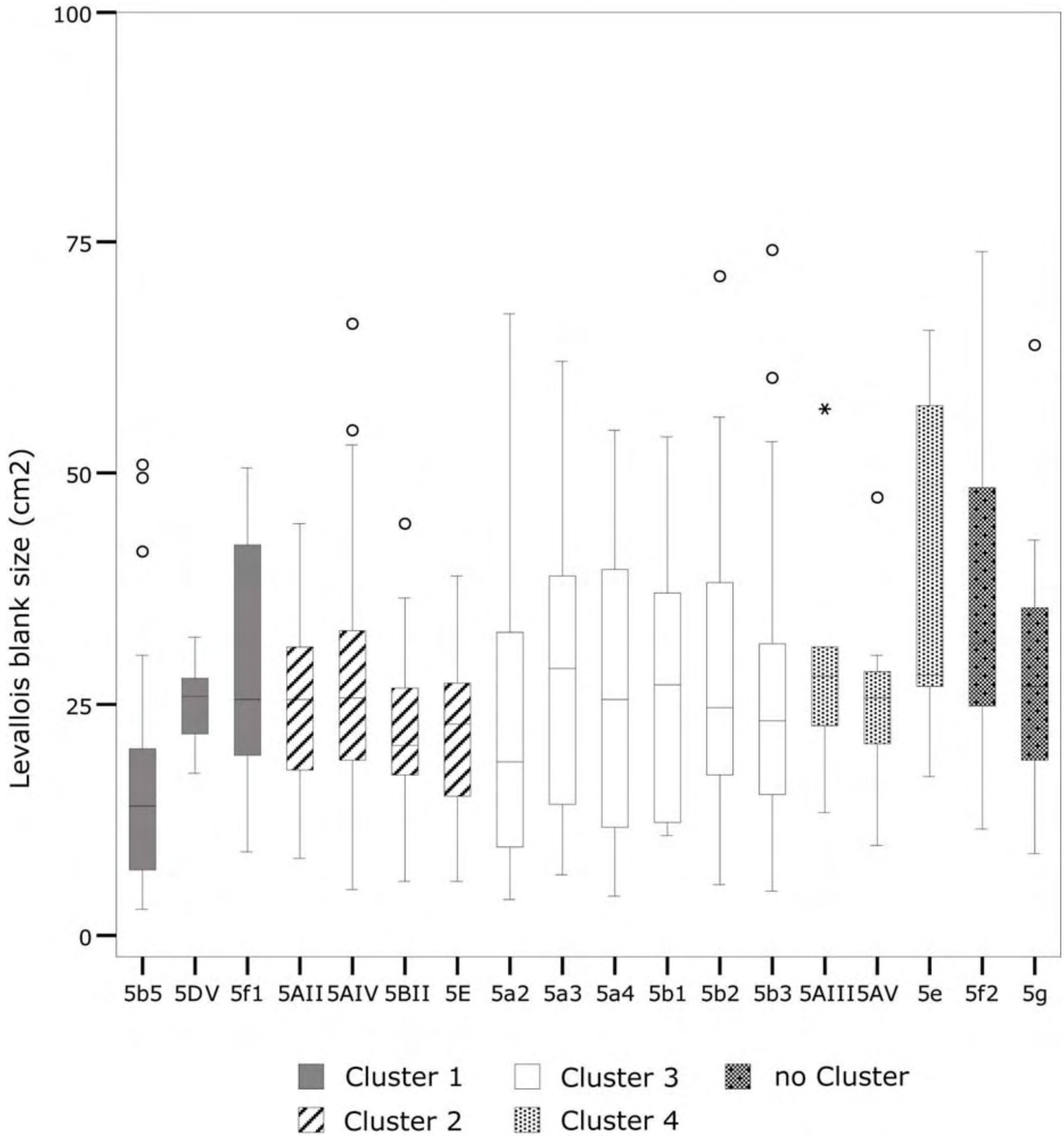


Fig.116: Boxplot showing the range of Levallois blank size within the four Mousterian assemblage clusters.

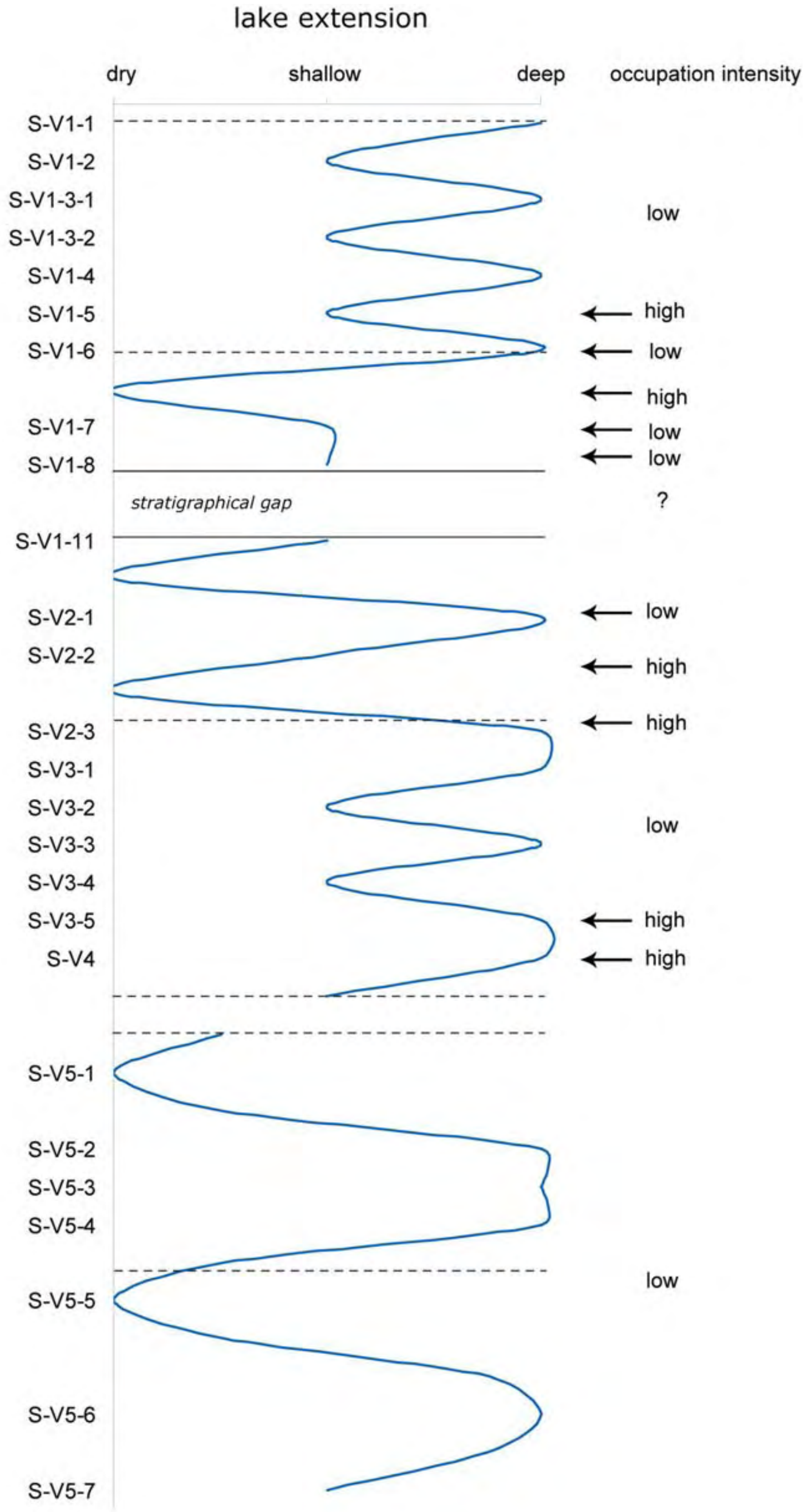


Fig.117: Relationship between differential intensities of Mousterian occupations and transgression vs. regressions of the water table in the spring of Hummal. The reconstruction is based on deposits of the southern sequence.

Fig.117

Fig.118: Map showing Levantine Mousterian sites discussed in the text and shown in Figure 130.

Fig.118

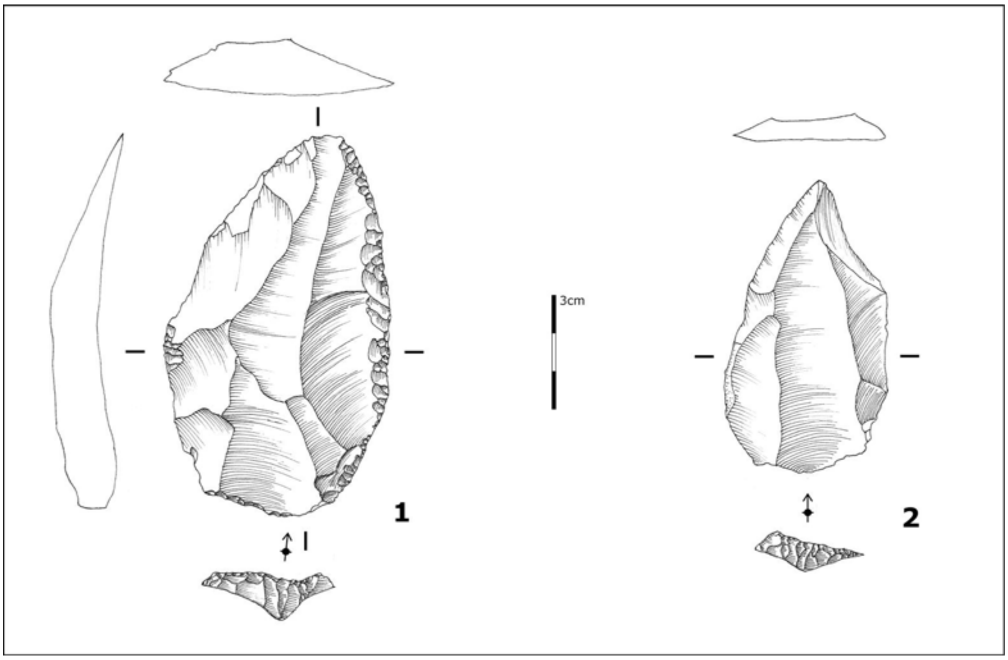


Fig.119: Selected artifacts from the Nadaouiyeh *remanié* sample. Nr.1: single side scraper; Nr.2: Levallois point.

Fig.119

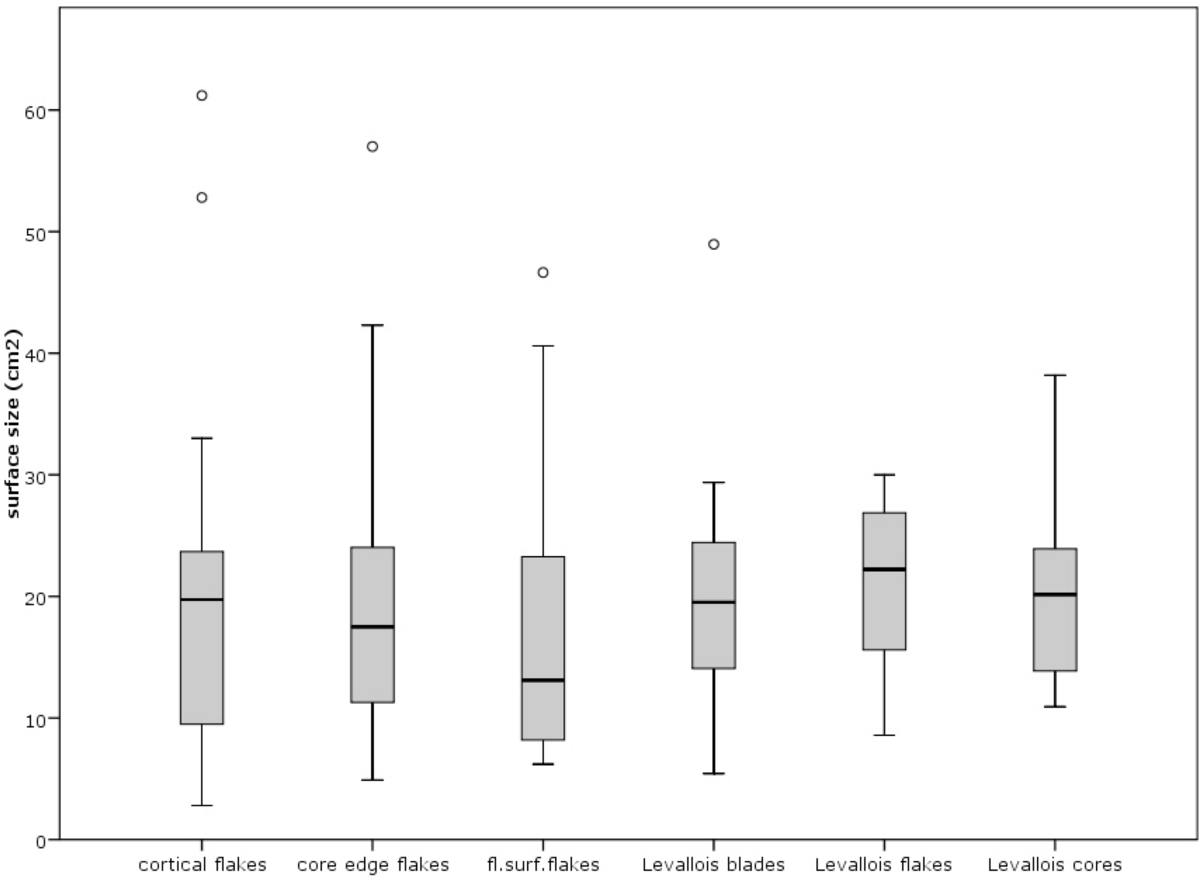


Fig.120: Boxplot showing the size range of diagnostic artifact categories in the Nadaouiyeh trench P50 sample.

Fig.120

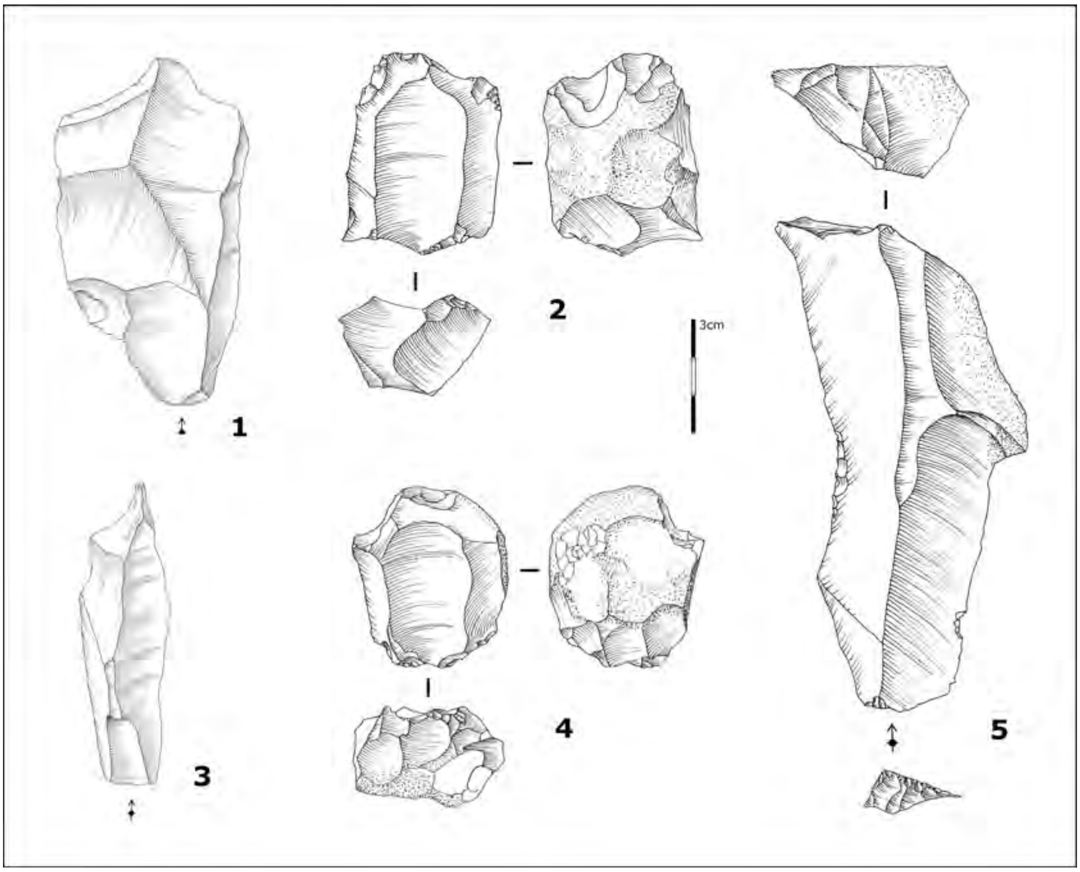


Fig.121: Selected artifacts from the Nadaouiyeh trench P50 sample. Nr.1: *débordant* Levallois flake; Nr.2: preferential Levallois flake core; Nr.3: second order Levallois blade ; Nr.4: preferential Levallois flake core; Nr.5: plunging core trimming blade.

Fig.121

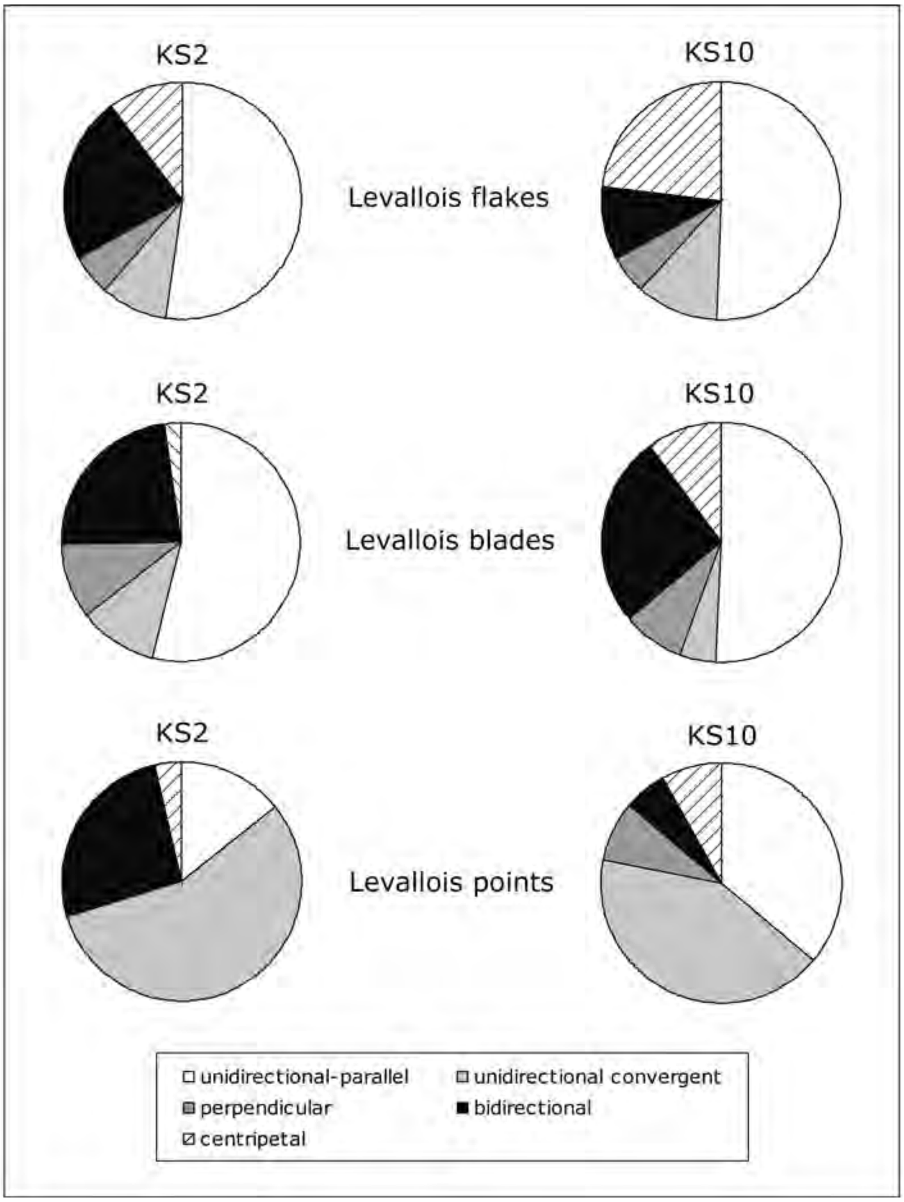


Fig.122: Comparison between Yabroud KS 2 and KS 10 in respect to scar pattern frequency distributions for Levallois flakes, Levallois blades and Levallois points.

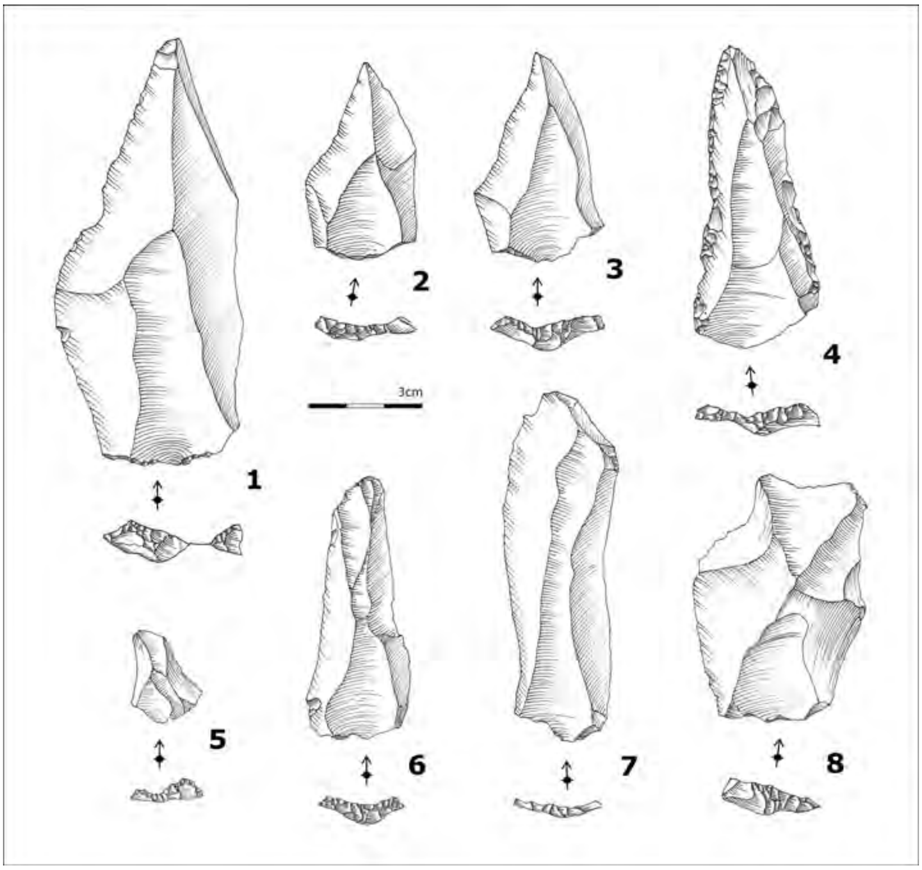
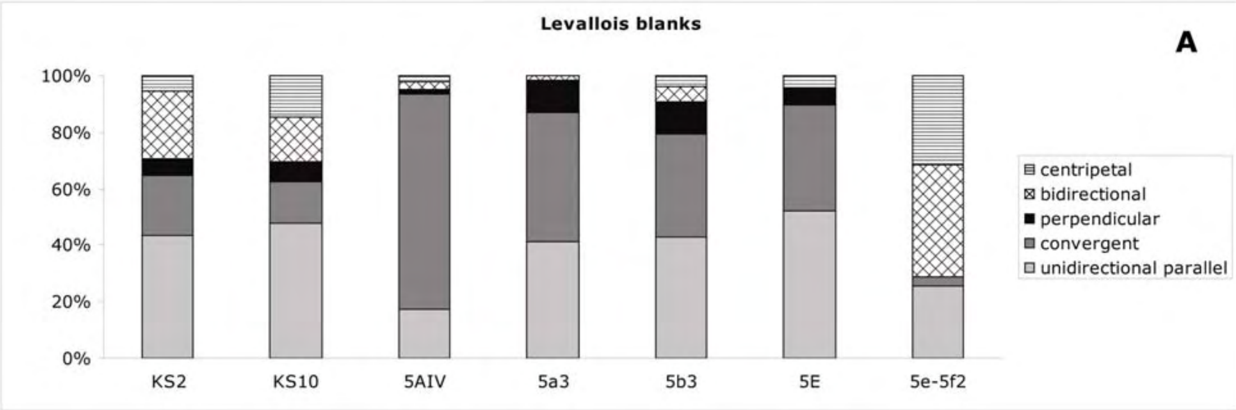


Fig.123: Typical Levallois blank types of KS 2 and KS 10 of Yabroud shelter I. Nr.1: elongated triangular flake with a bidirectional scar pattern (KS 2); Nr.2-3: Levallois points with a bidirectional scar pattern (Nr.2: KS 10, Nr.3: KS 2); Nr.4: elongated Mousterian point (KS 2); Nr.5: small Levallois flake with a centripetal scar pattern (KS 10); Nr.6-7: Levallois blades with bidirectional and unidirectional scar patterns (KS 10); Nr.8: preferential Levallois flake (KS 10).

Fig.123



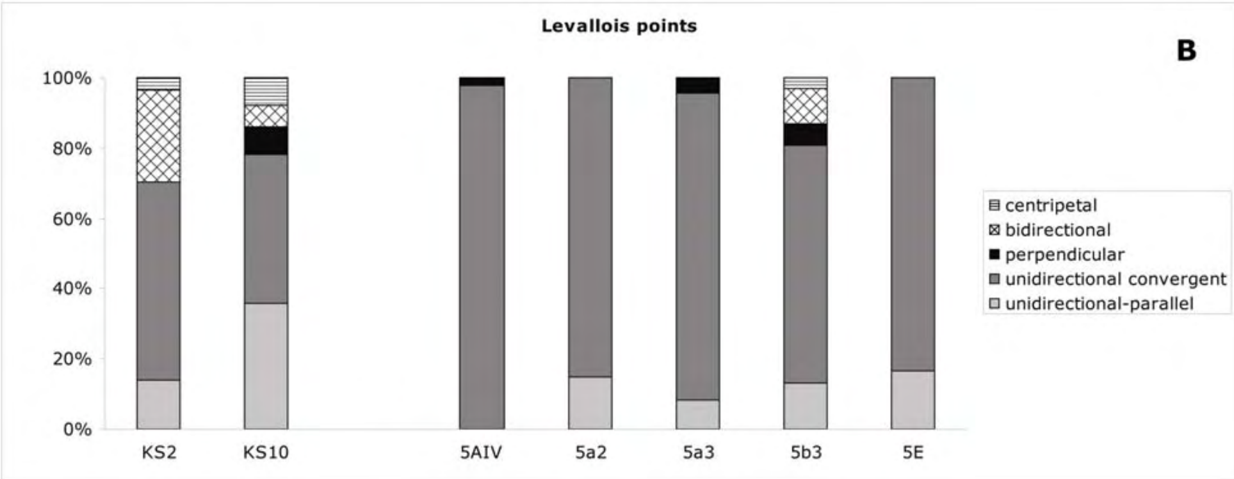


Fig.124: Comparison between Yabroud KS 2, KS 10, and selected Hummal assemblages in respect to scar pattern frequency distributions of Levallois blanks in general (A) and Levallois points in particular (B).

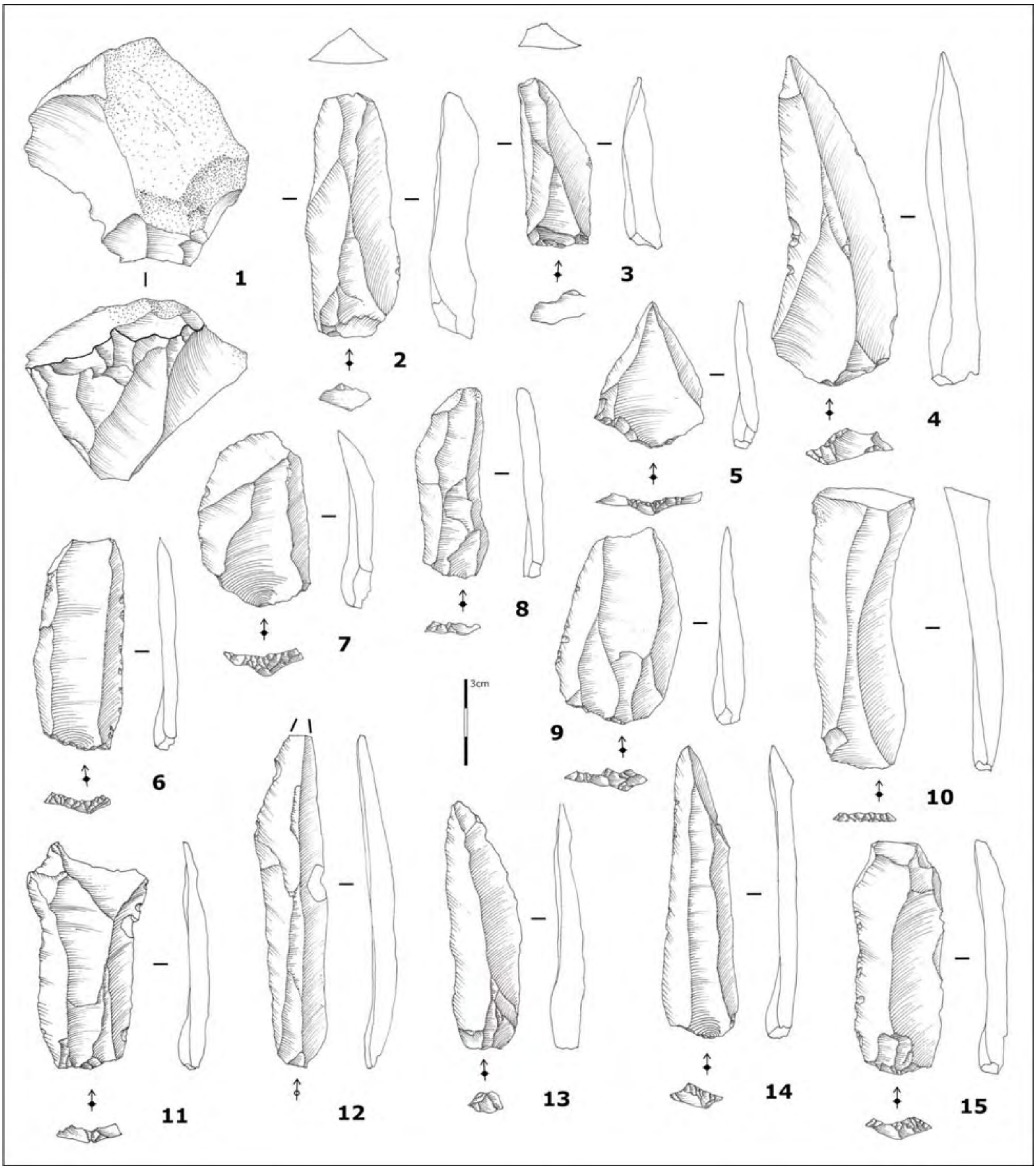


Fig.125: Selected artifacts from Tabun unit IX. Nr.1: prismatic blade core; Nr.2-3: prismatic blades; Nr.4: elongated, asymmetric Levallois point; Nr.5: broad-based Levallois point; Nr.6: Levallois blade with unidirectional scar pattern; Nr.7: Levallois flake with convergent scar pattern; Nr.8-9: Levallois blade and Levallois flake with bidirectional scar patterns; Nr.10: Levallois blade with unidirectional scar pattern; Nr.11-12: Levallois flake and blade with bidirectional scar patterns; Nr.13-14: elongated Levallois points; Nr.14: Levallois blade with unidirectional scar pattern.

Fig.125

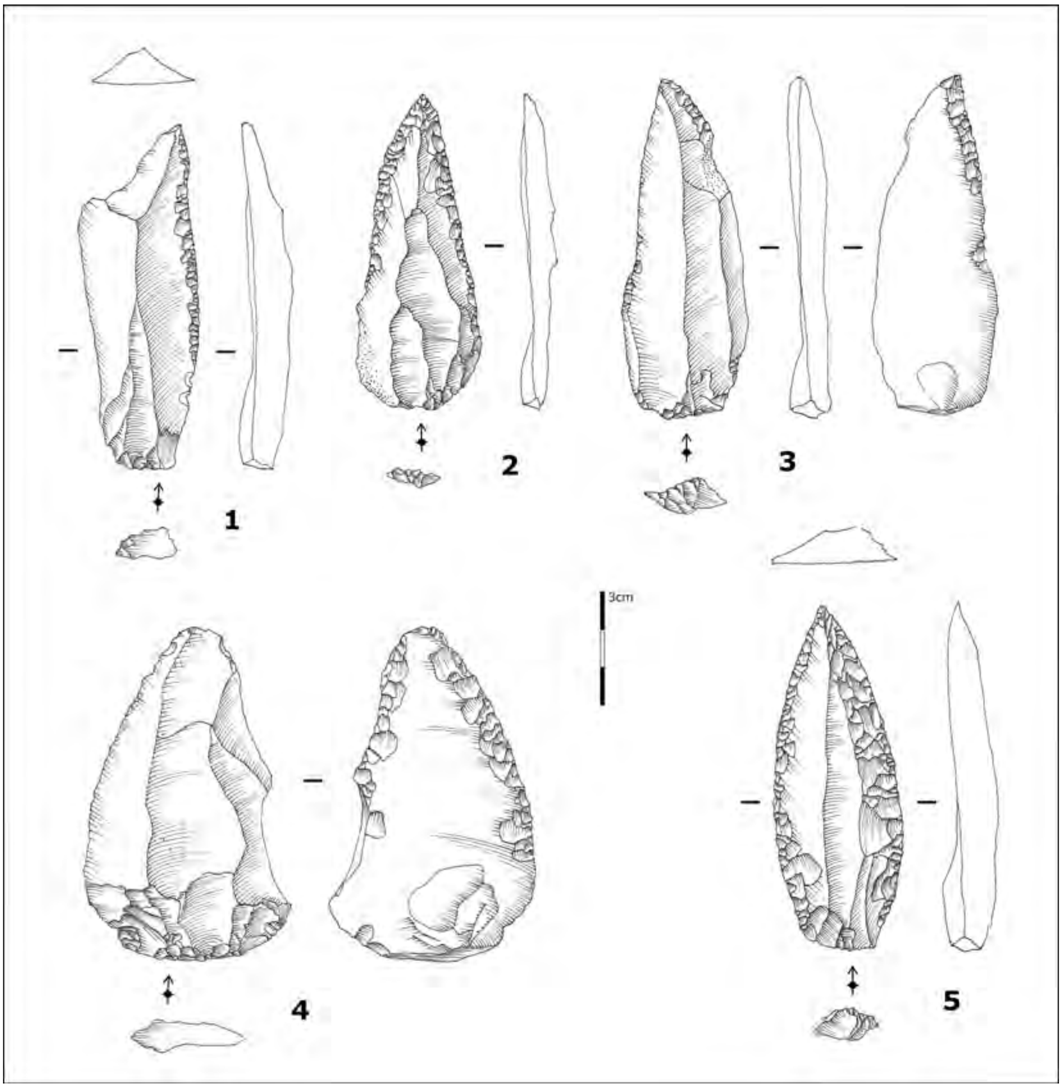


Fig.126: Selected retouched artifacts from Tabun unit IX. Nr.1: single convex side scraper; Nr.2: elongated Mousterian points; Nr.3: alternate retouched side scraper; Nr.4: double scraper on ventral face; Nr.5: retouched point of Hummalian type.

Fig.126

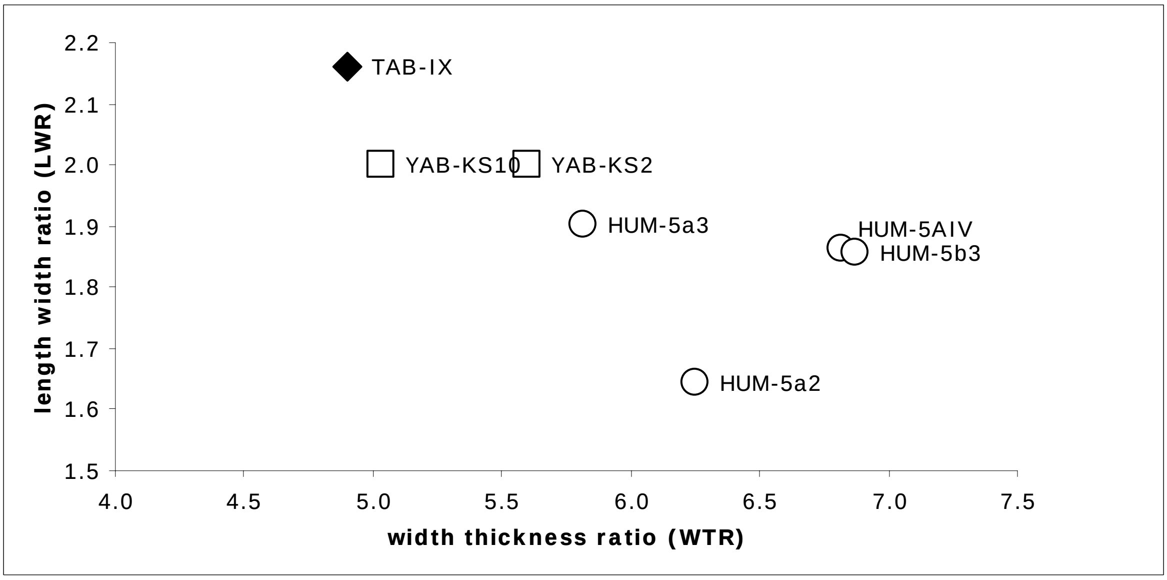


Fig.127: Relationship between elongation (LWR) and the width thickness ratio (WTR) among Levallois points samples from Tabun unit IX, Yabroud KS 2, Yabroud KS 10, and selected Hummal levels.

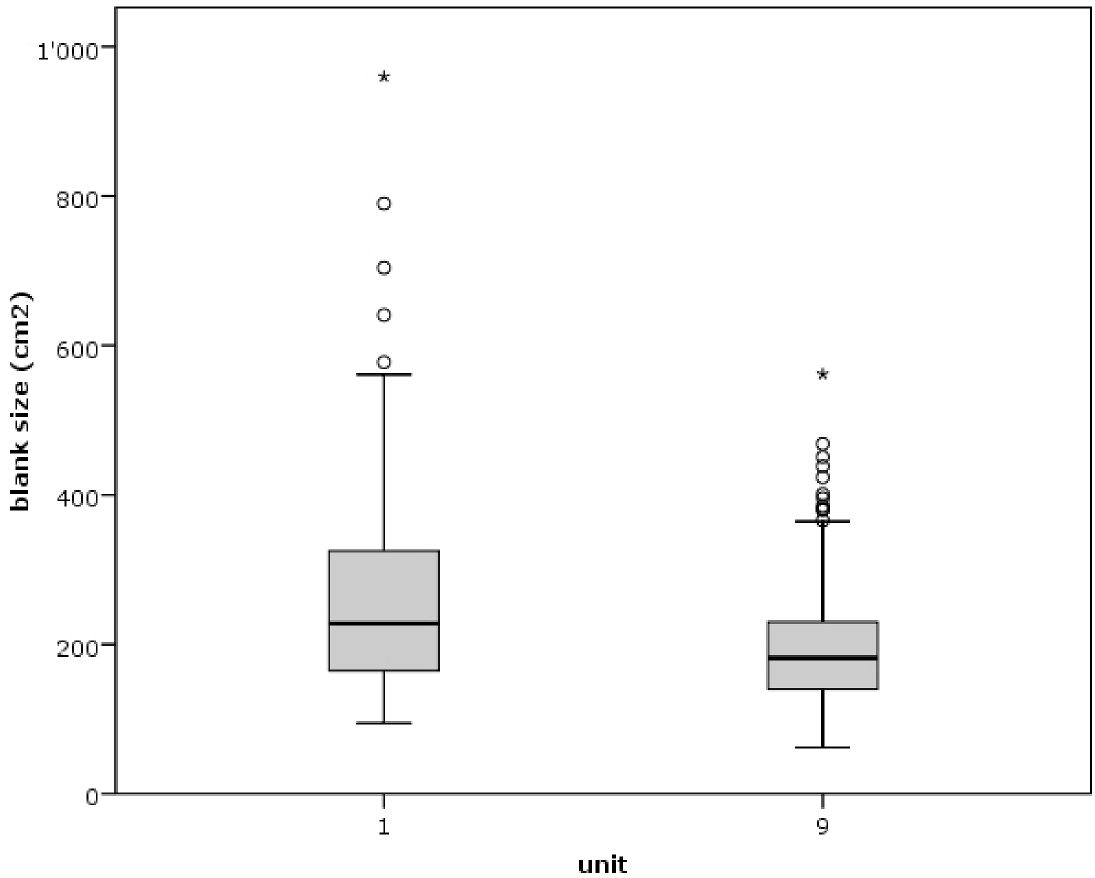


Fig.128: Comparison of blank size range between units IX and I of Tabun.

Fig.128

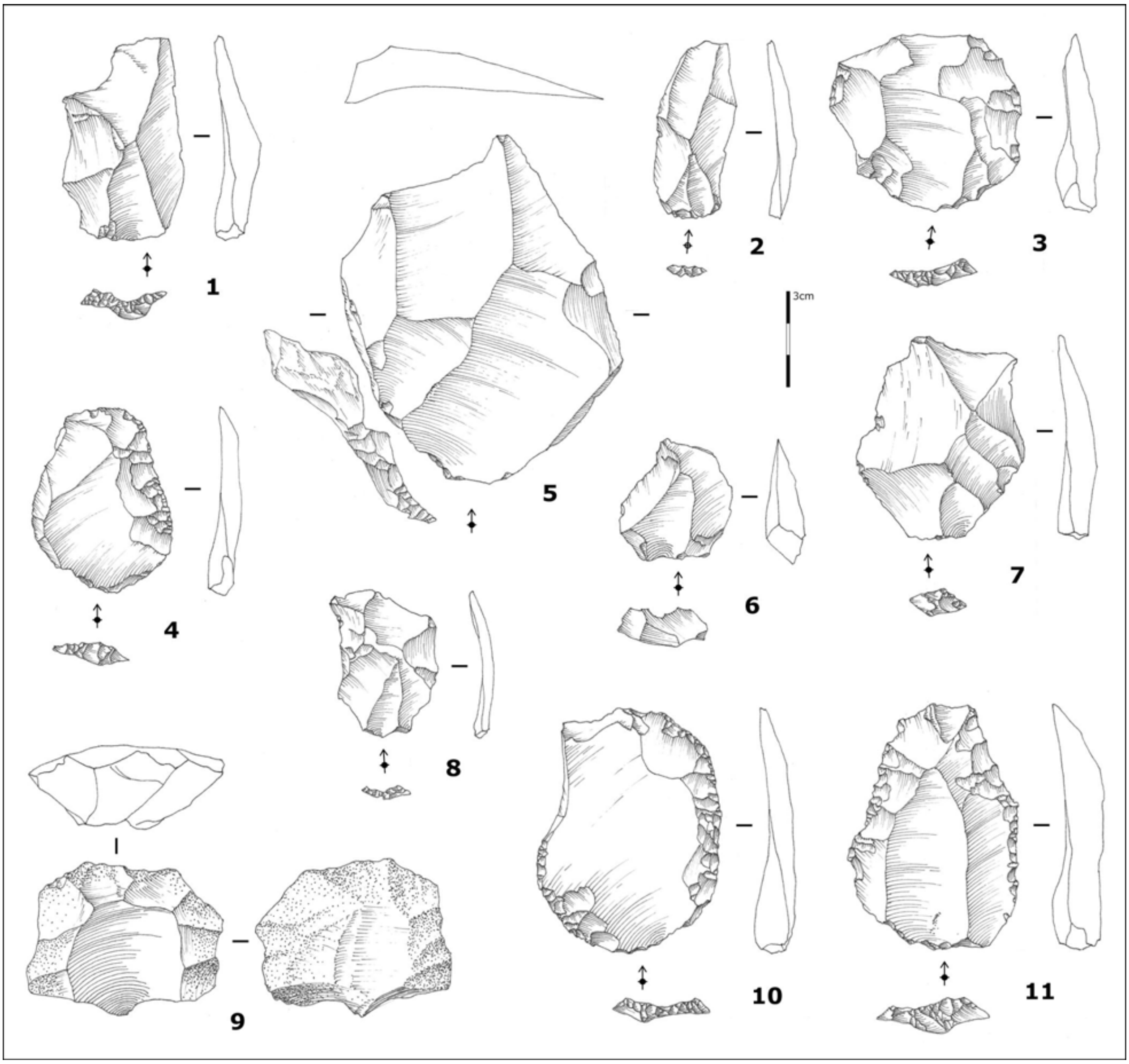


Fig.129: Selected artifacts from Tabun unit I. Nr.1: second order Levallois flake with centripetal scar pattern; Nr.2: Levallois blade with bidirectional scar pattern; Nr.3: preferential Levallois flake with centripetal scar pattern; Nr.4: single side scraper made on a second order Levallois flake; Nr.5: *débordant* Levallois flake with centripetal scar pattern; Nr.6: small non-Levallois flake; Nr.7-8: preferential flakes with centripetal scar pattern; Nr.9: lineal-type Levallois flake core; Nr.10: double side scraper made on second order Levallois flake; Nr.11: double side scraper made on preferential Levallois flake.

Fig.129

Fig.130

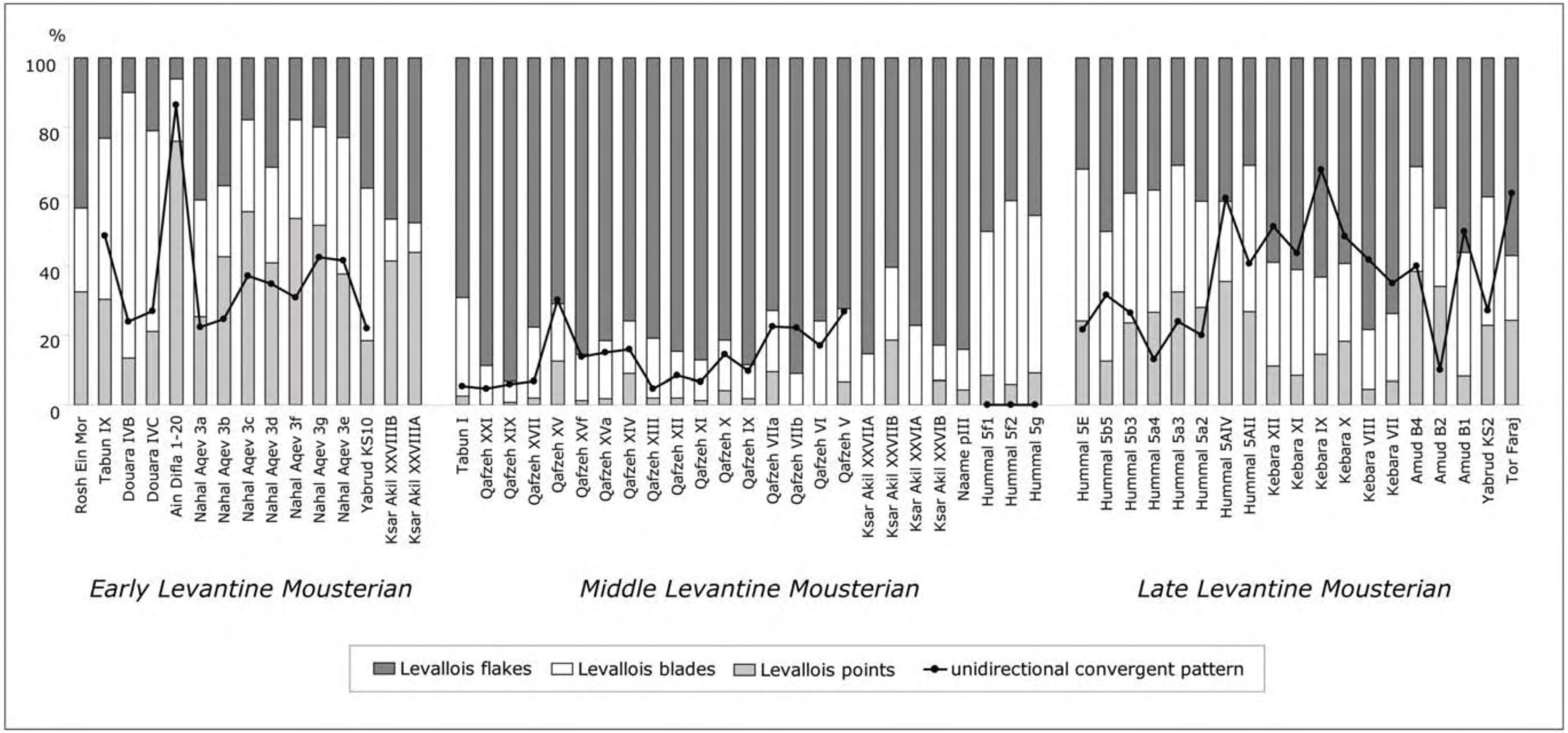


Fig.130: Frequency distribution of Levallois flakes, blades, points and of the unidirectional convergent scar pattern visible on these blanks of selected Levantine Mousterian key-sites. The grouping of assemblages into Mousterian phases follows conventional propositions. The ordering of assemblages within each Mousterian complex is arbitrary and does not imply a chronological sequence; Note that scar pattern frequencies were not available for each assemblage. Data were taken as follows: Rosh Ein Mor: Crew 1975, Douara IV: Nishiaki 1989, Ain Difla: Lindly & Clark 1987; Mustafa & Clark, in press.; Ksar Akil: Marks & Volkman 1986; Qafzeh: Hovers 2009; Naame: Copeland & Moloney 1998; Kebara: Meignen & Bar-Yosef 1991; Amud: Ohnuma & Akazawa 1988; Hovers 1998; Tor Faraj: Henry 1995, 2003.

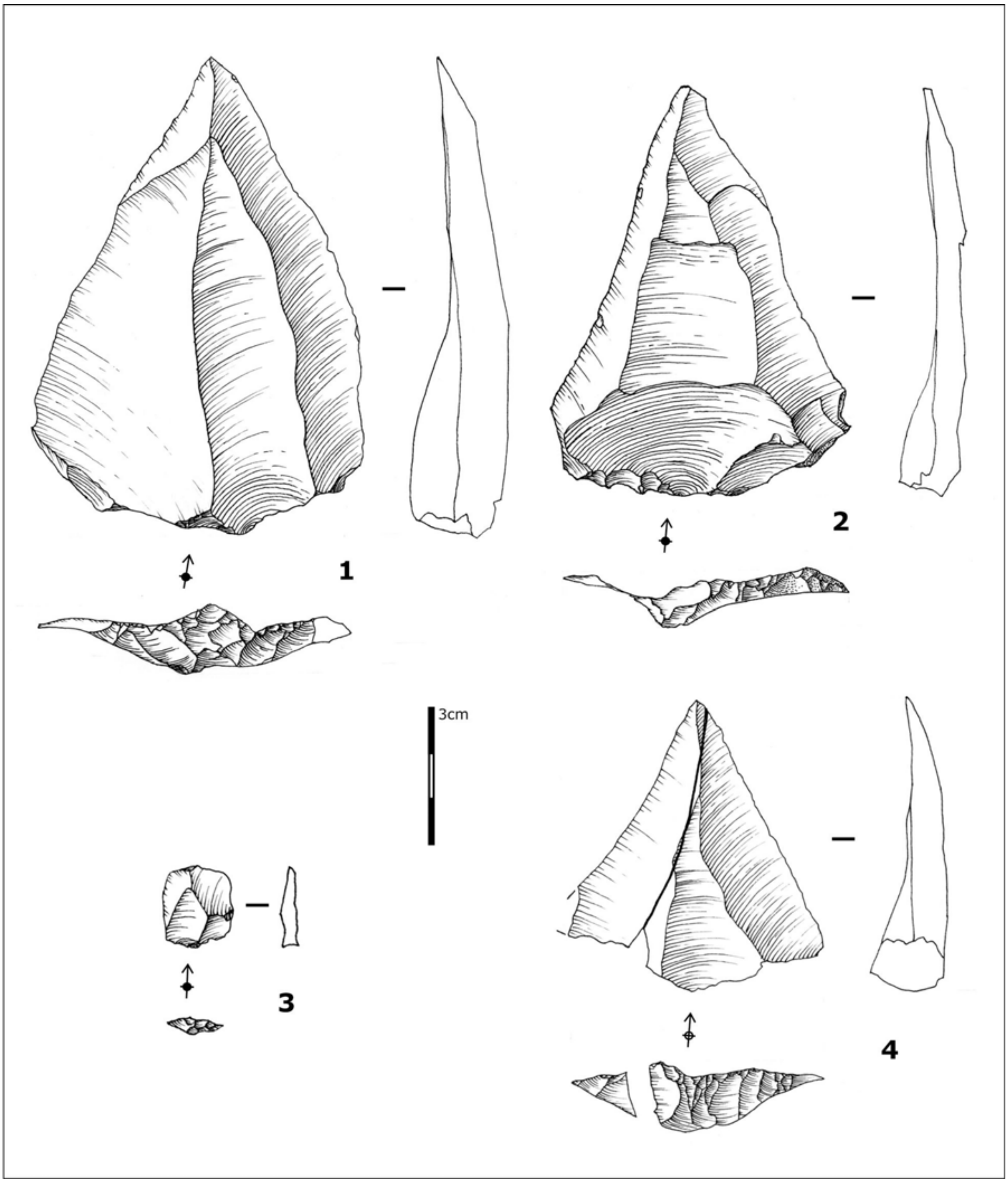


Fig.131: Selected artifacts of assemblage 5a1. Nr.1,2 and 4: large, broad-based Levallois points; Nr.3: small Levallois flake with centripetal scar pattern.

Fig.131

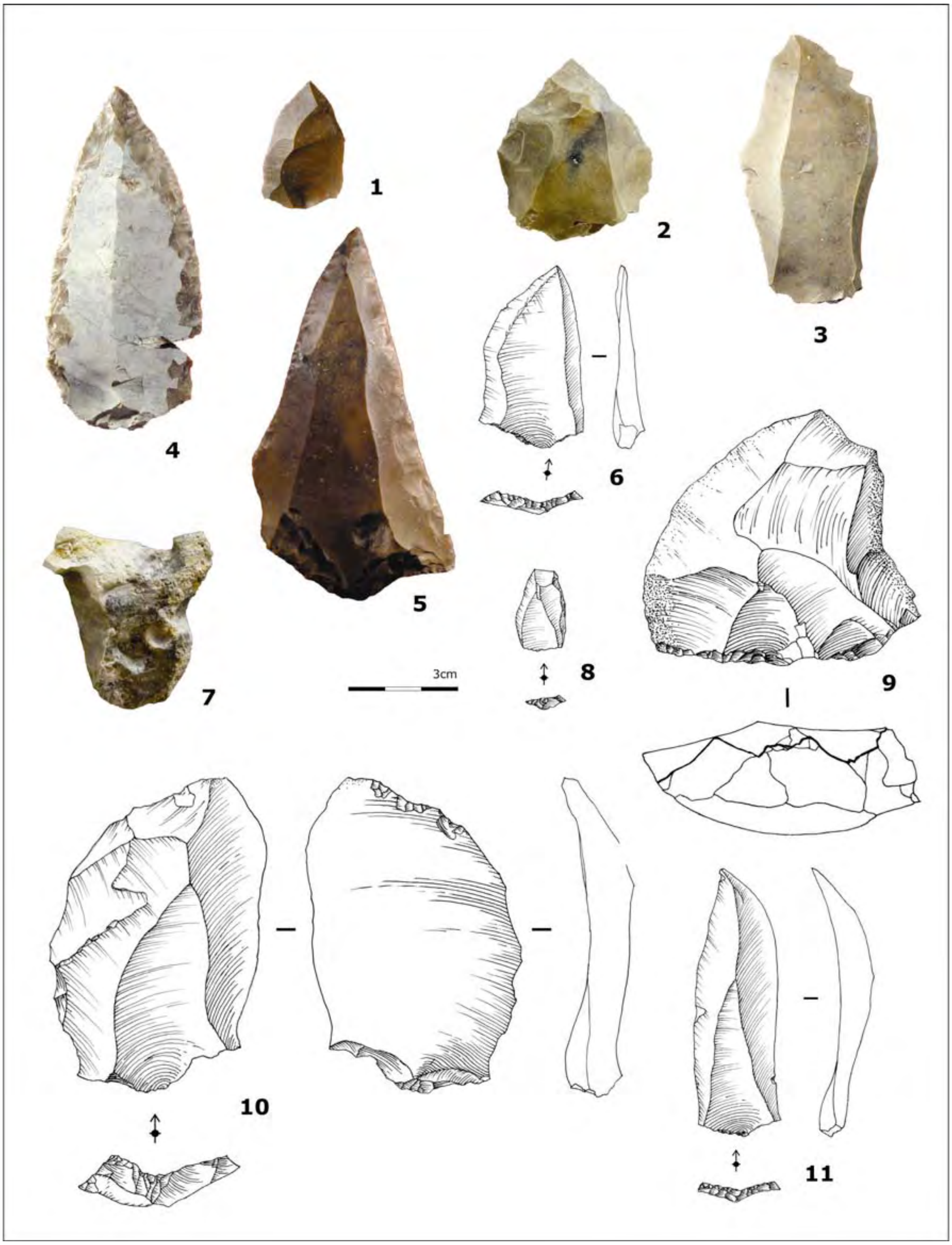


Fig.132: Selected artifacts of assemblage 5a2. Nr.1: small Levallois point; Nr.2: heavily retouched convergent side scraper; Nr.3: Levallois blade; Nr.4: recycled blade modified into a convergent side scraper; Nr.5: large, single straight side scraper; Nr.6: triangular Levallois flake; Nr.7: cortical fake; Nr.8: small Levallois flake; Nr.9: recurrent Levallois point core; Nr.10: Levallois flake with use wear traces on ventral face; Nr.11: "leaf-shaped" Levallois point. (photos taken by J.-B. Schmid and C. Leconte).

Fig.132

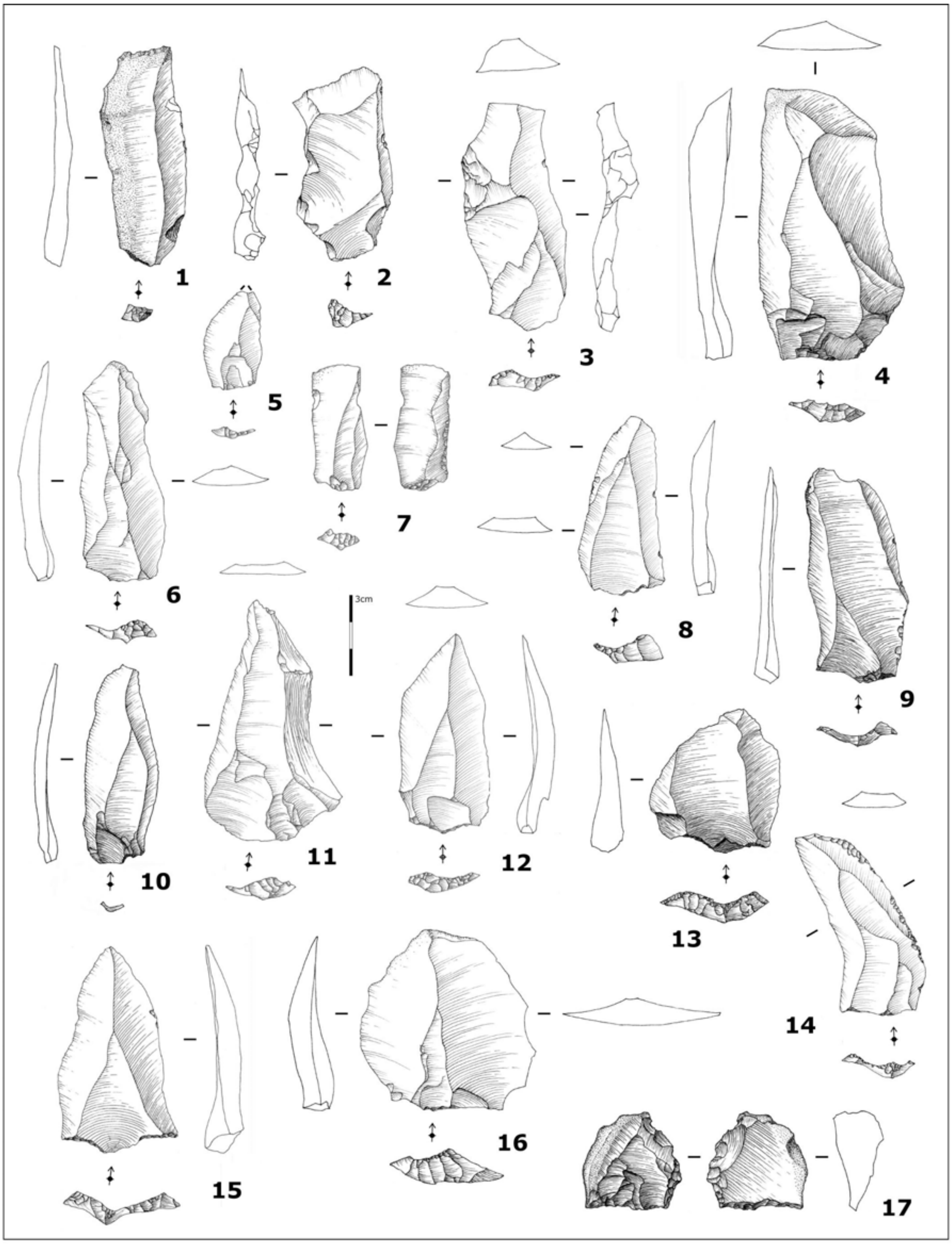


Fig.133: Selected artifacts of assemblage 5a3. Nr.1: naturally backed knife; Nr.2-3: core edge flakes; Nr.4: Levallois flake; Nr.5: small triangular Levallois flake; Nr.6: Levallois blade (by-product of Levallois point production); Nr.7: non-Levallois blade; Nr.8: Levallois point (broken at distal tip); Nr.9: Levallois blade; Nr.10: triangular Levallois blade related to Levallois point production; Nr.11-12: Levallois points; Nr.13: Levallois flake; Nr.14: atypical, partially retouched Levallois point; Nr.15: Levallois point; Nr.16: Levallois flake; Nr.17: core on flake.

Fig.133

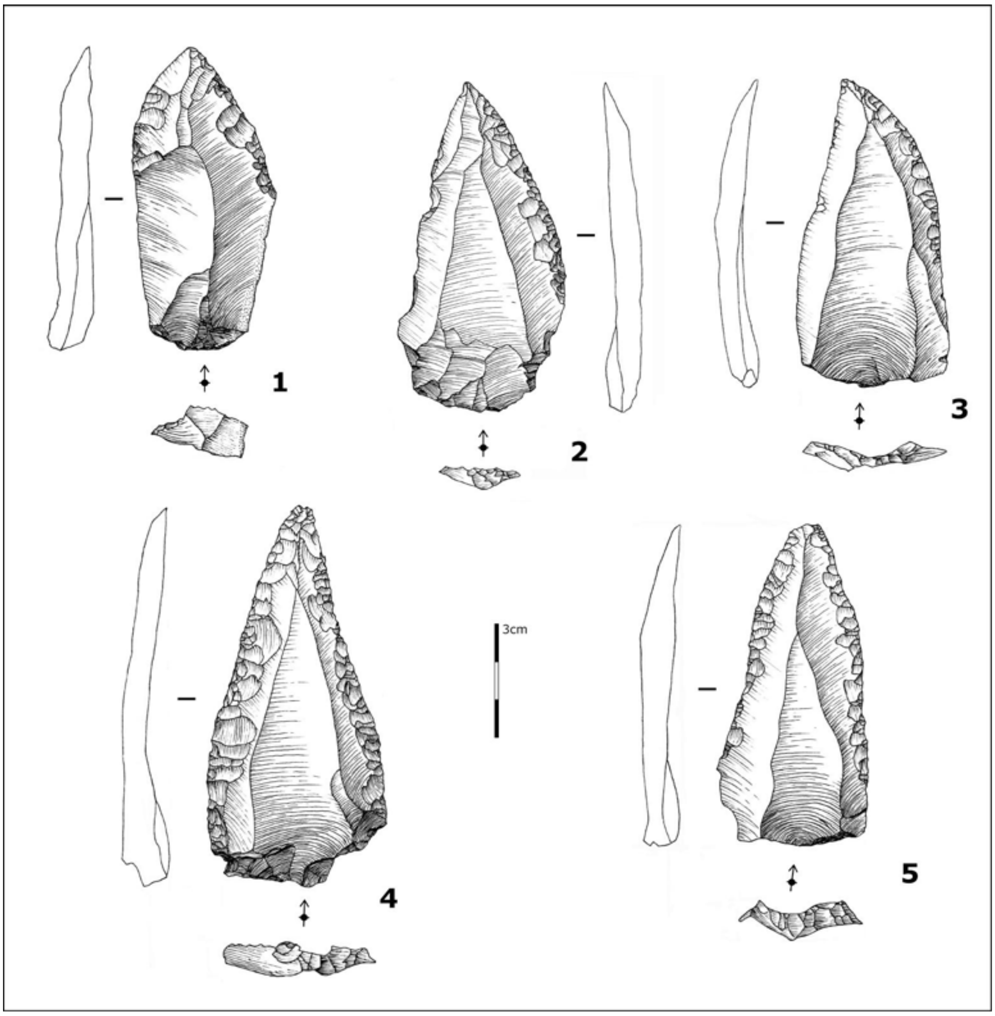


Fig.134: Selected retouched tools of assemblage 5a3. Nr.1: double side scraper made on non-Levallois blade; Nr.2-3: single convex side scrapers made on Levallois points; Nr.4: elongated Mousterian point; Nr.5: convergent scraper made on Levallois point.

Fig.134

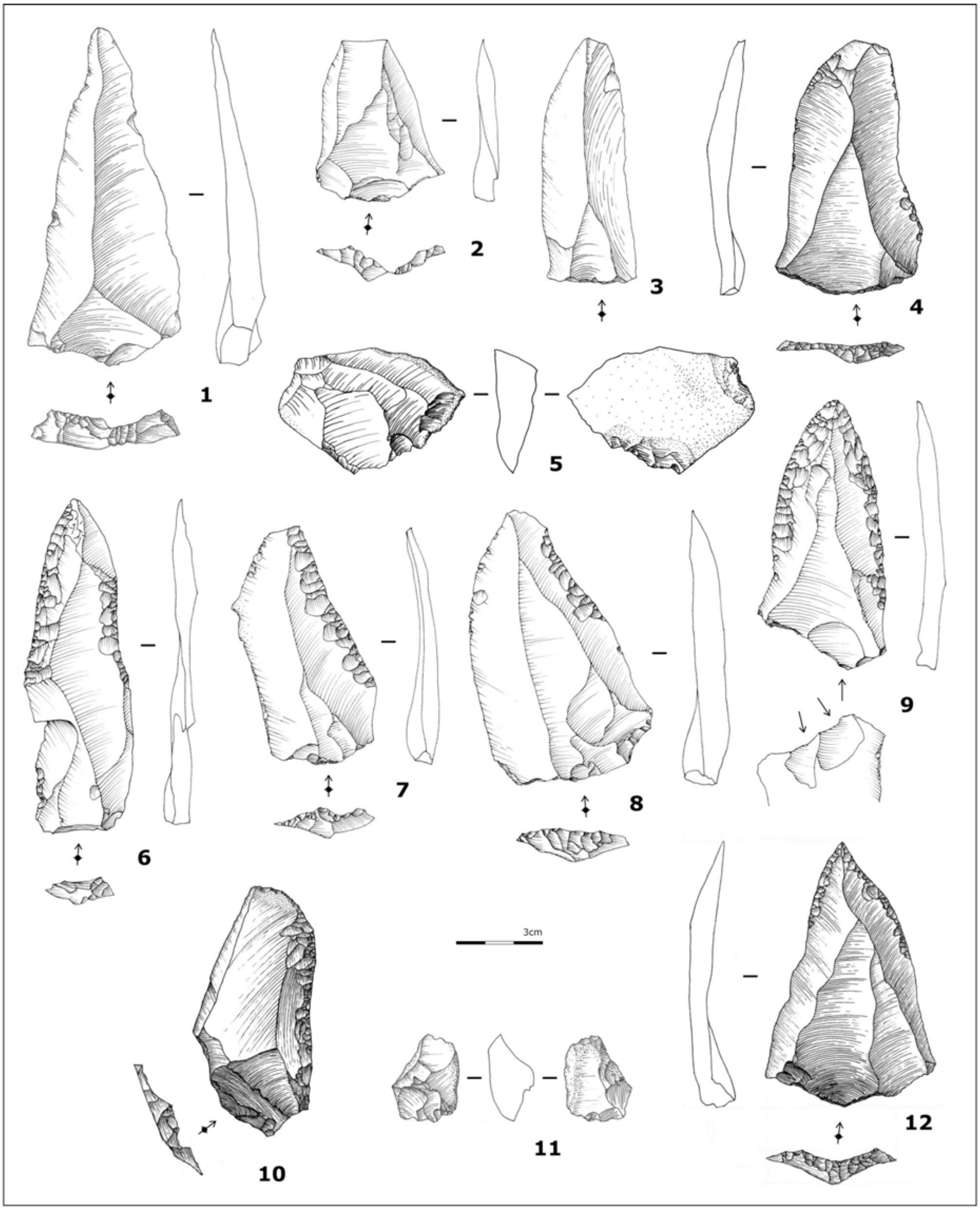


Fig.135: Selected artifacts and retouched tools of assemblage 5a4. Nr.1:Levallois point; Nr.2: Levallois flake; Nr.3: atypical Levallois point with perpendicular scar pattern; Nr.4: partially retouched Levallois point; Nr.5: simple flake core; Nr.6: convex-concave double side scraper made on Levallois blade; Nr.7: single concave side scraper; Nr.8: partially retouched Levallois point; Nr.9: Mousterian point with secondary removals at its proximal base; Nr.10: single concave side scraper made on core edge flake; Nr.11: small flake core; Nr.12: retouched Levallois point.

Fig.135

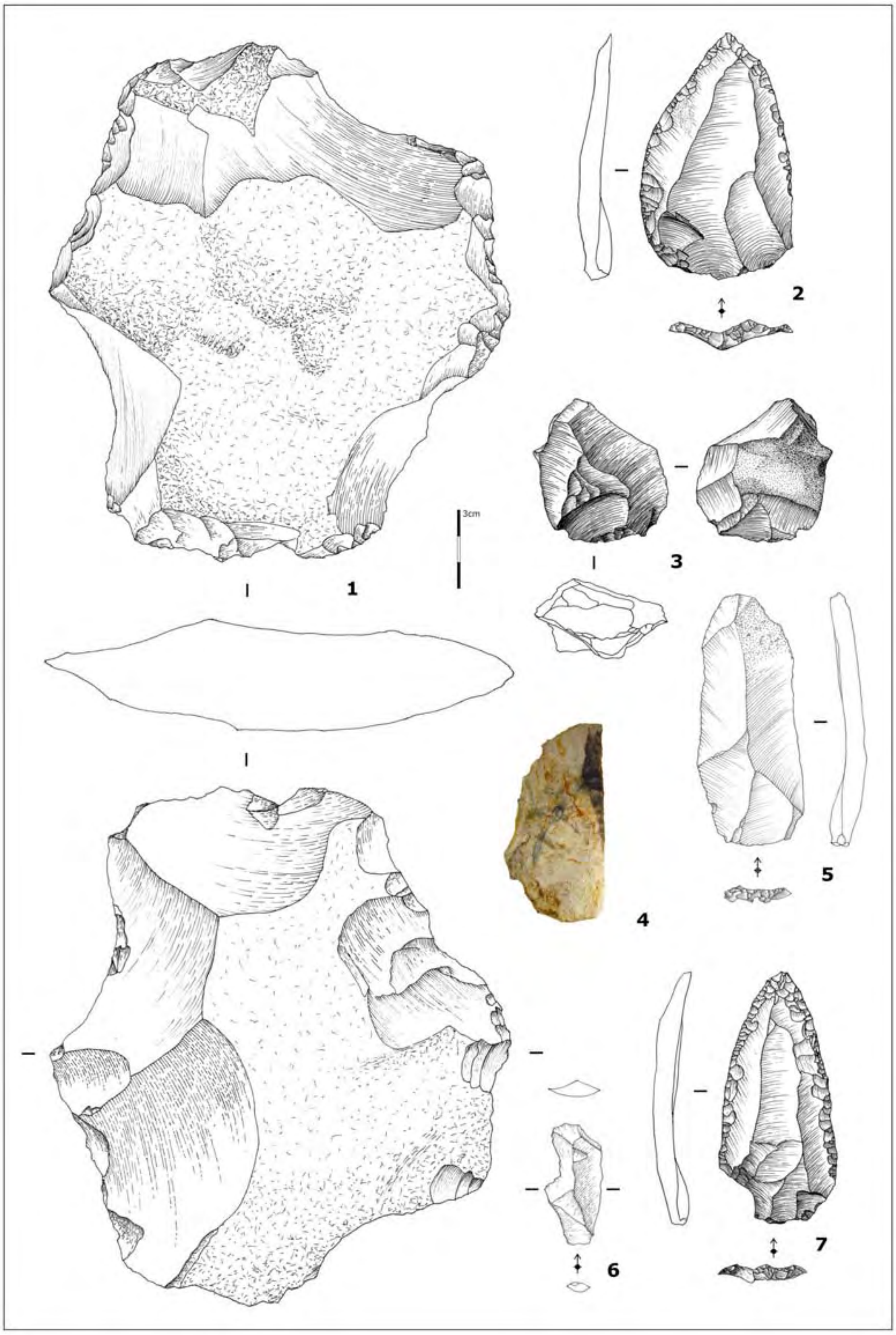


Fig.136: Selected artifacts and retouched tools of assemblage 5b1. Nr.1: chopping tool made on a limestone slab; Nr.2: double convergent scraper; Nr.3: exhausted Levallois point core; Nr.4: flake recycled into a single straight edge scraper; Nr.5: Levallois blade; Nr.6: non-Levallois blade made of limestone; Nr.7: double convergent scraper.

Fig.136

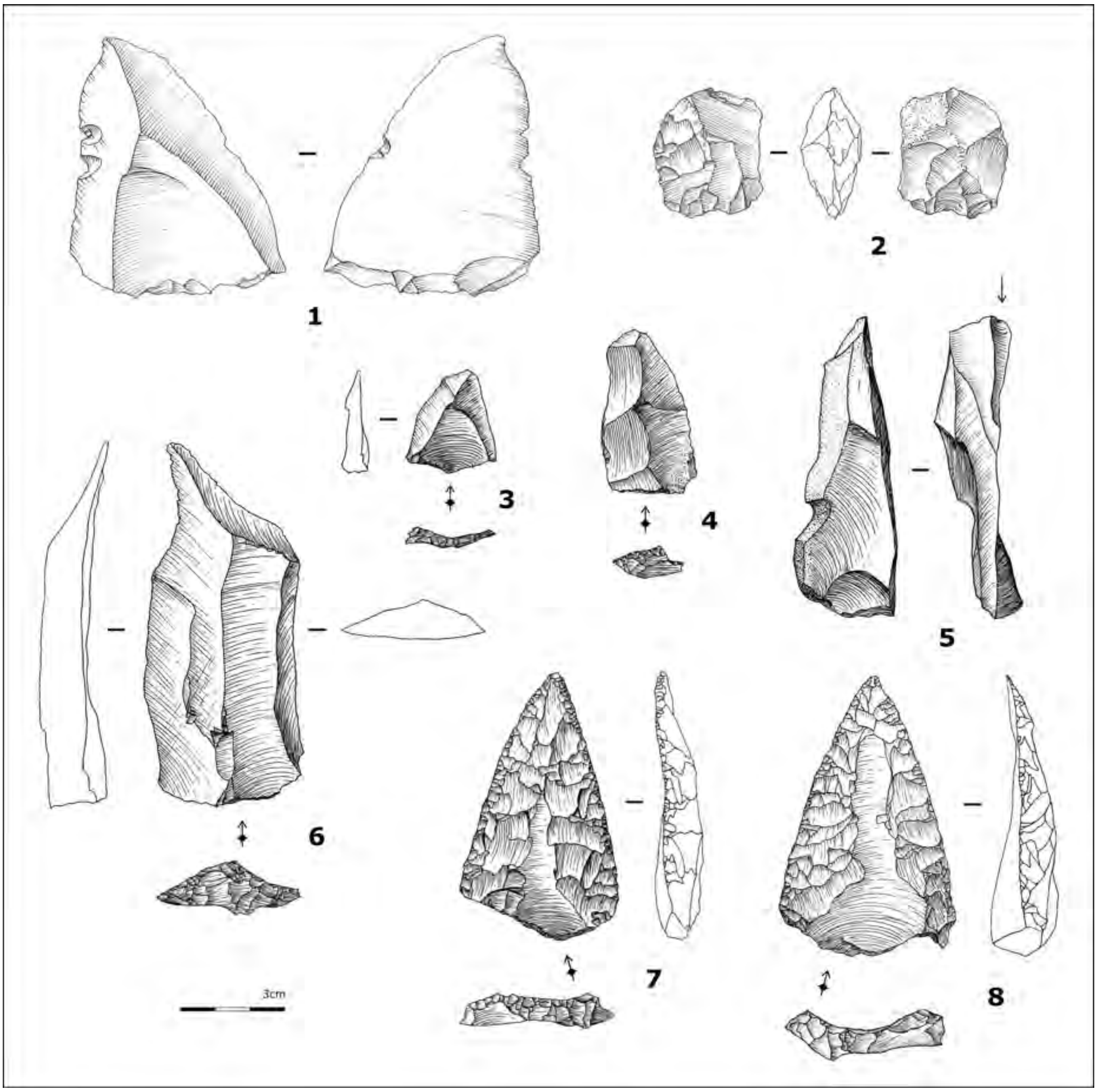


Fig.137: Selected artifacts and retouched tools of assemblage 5b2. Nr.1: Levallois point with proximal thinning; Nr.2: simple flake core; Nr.3: small Levallois point; Nr.4: flaking surface preparation flake; Nr.5: burin made on core edge flake; Nr.6: Levallois flake; Nr.7-8: heavily retouched Mousterian points.

Fig.137

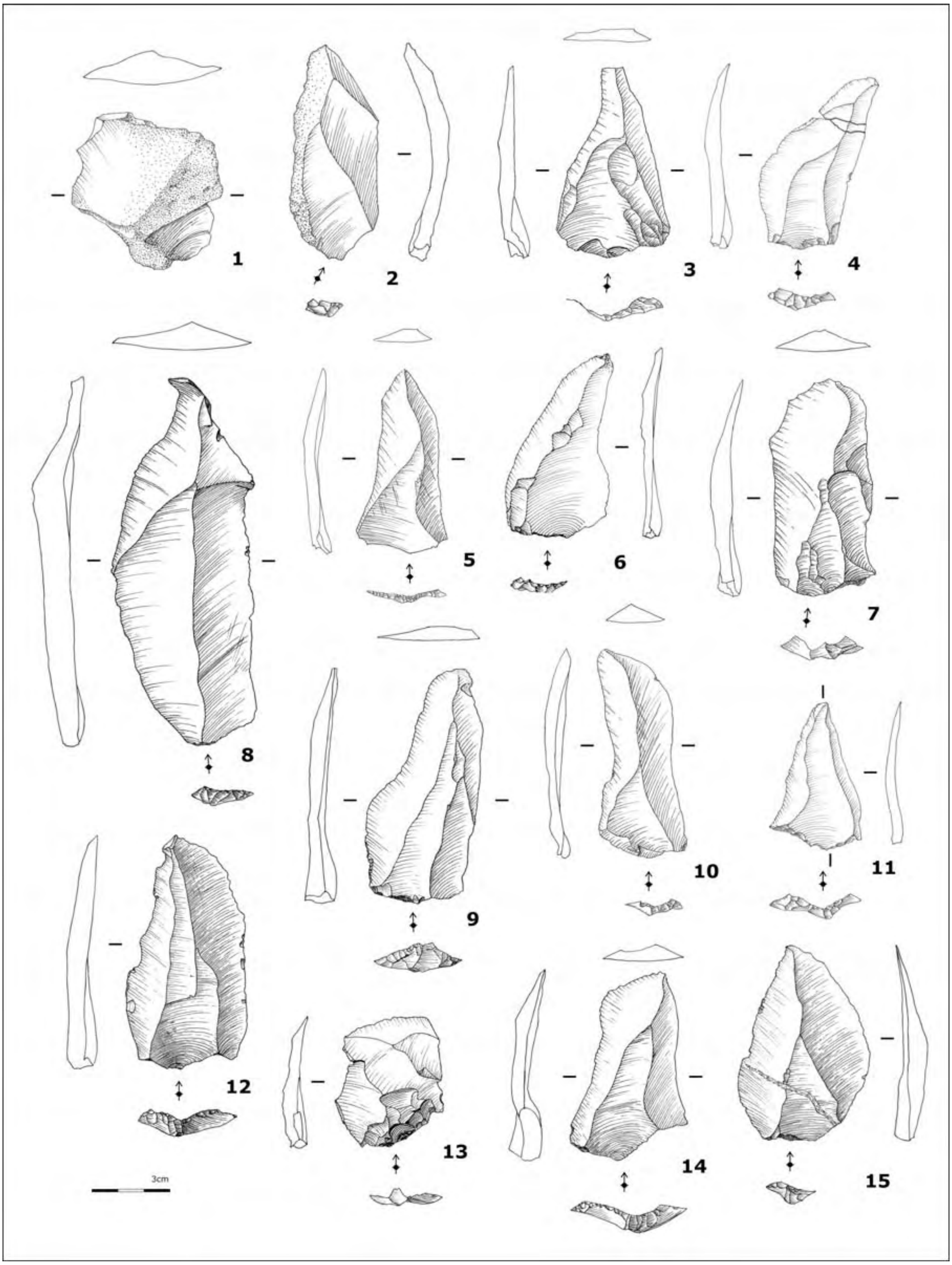


Fig.138: Selected artifacts of assemblage 5b3. Nr.1: cortical flake; Nr.2: naturally backed knife; Nr.3-5: Levallois points; Nr.6: flaking surface preparation flake; Nr.7-8: Levallois blades; Nr.9-10: triangular Levallois blades; Nr.11: Levallois point; Nr.12: triangular Levallois blade; Nr.13: striking platform preparation flake; Nr.14-15: Levallois points.

Fig.138

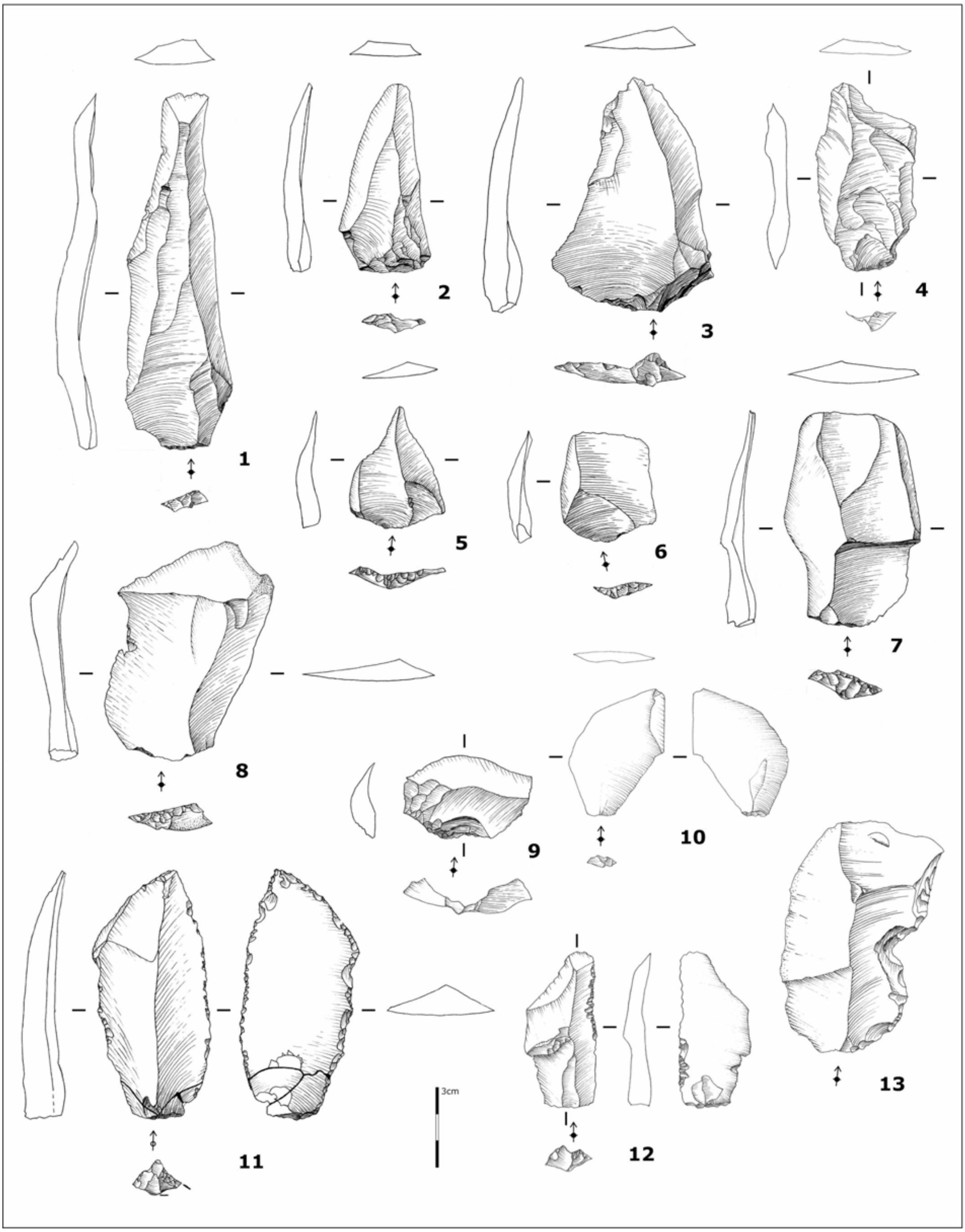


Fig.139: Selected artifacts of assemblage 5b3. Nr.1: Levallois blade; Nr.2: Levallois point (broken at distal tip); Nr.3: flaking surface preparation flake; Nr.4: Levallois flake; Nr.5: flaking surface preparation flake; Nr.6-8: Levallois flakes; Nr.9: striking platform preparation flake; Nr.10: Kombewa flake; Nr.11: edge-damaged Levallois blade; Nr.12: flaking surface preparation flake with alternating retouch; Nr.13: notched piece.

Fig.139

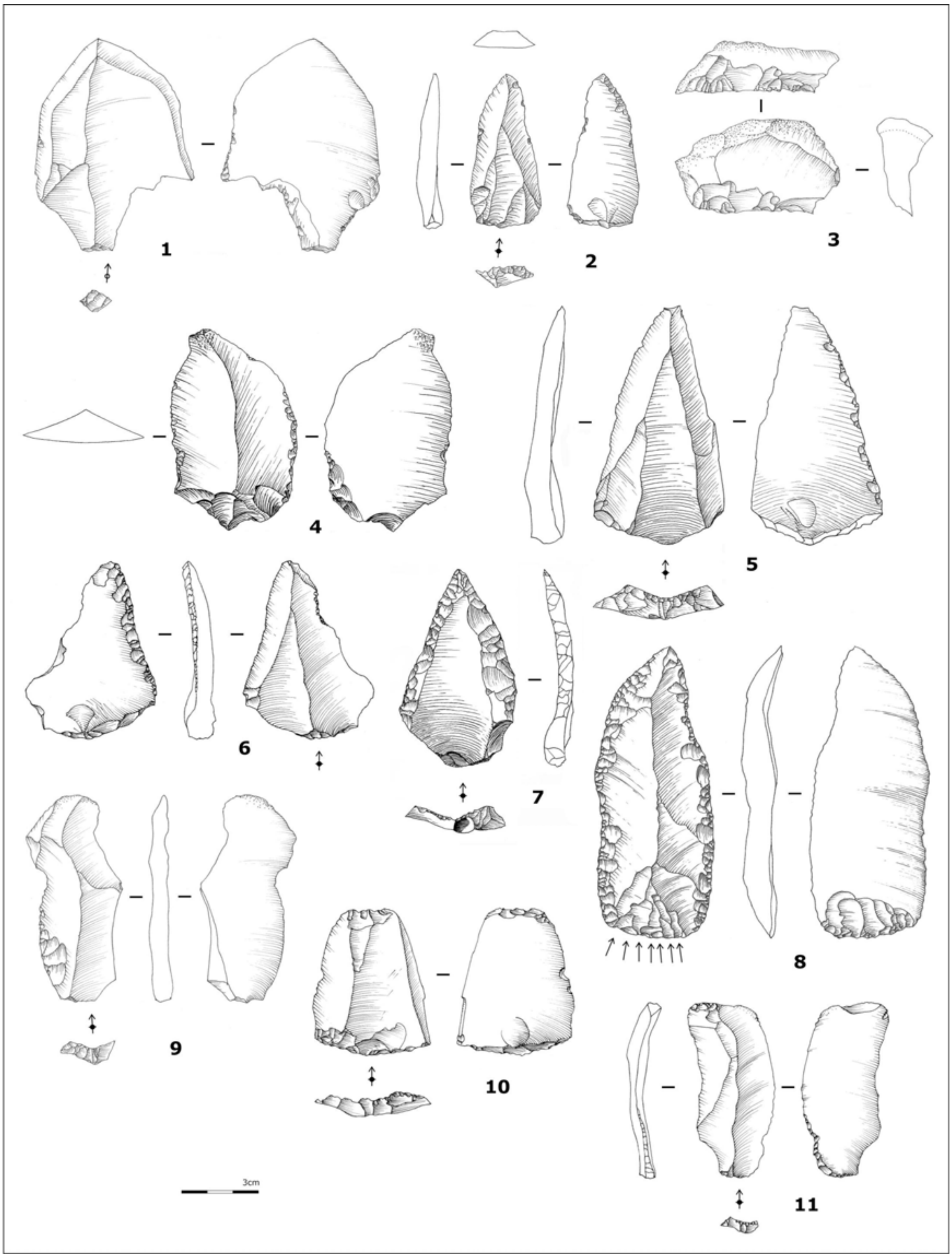


Fig.140: Selected tools of assemblage 5b3. Nr.1: partially retouched flake; Nr.2: Levallois point with retouch on ventral face; Nr.3: side scraper with abrupt retouch made on naturally backed knife; Nr.4: single convex side scraper used as core on flake; Nr.5: Levallois point with use wear on ventral face; Nr.6: side scraper on ventral face; Nr.7: Mousterian point; Nr.8: double side scraper with basal thinning; Nr.9: partially retouched Levallois blade; Nr.10: plunging flake; Nr.11: *débordant* Levallois blade with end-retouch.

Fig.140

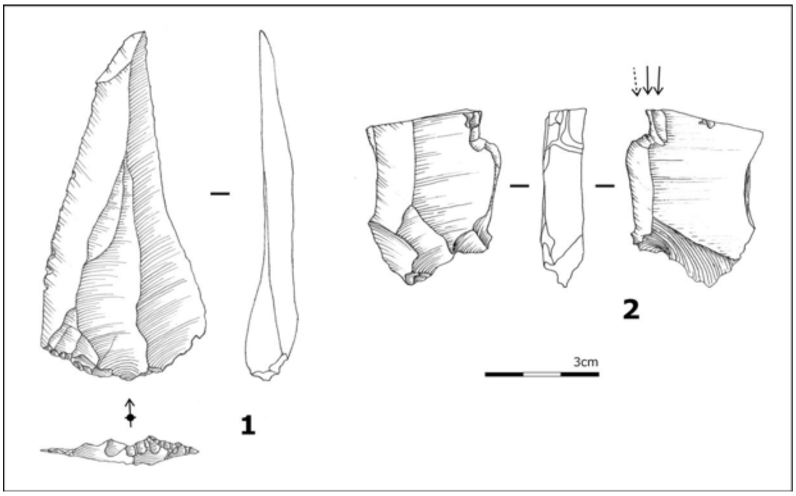


Fig.141: Selected artifacts of assemblage 5b4. Nr.1: elongated Levallois point; Nr.2: atypical burin made on flake fragment.

Fig.141

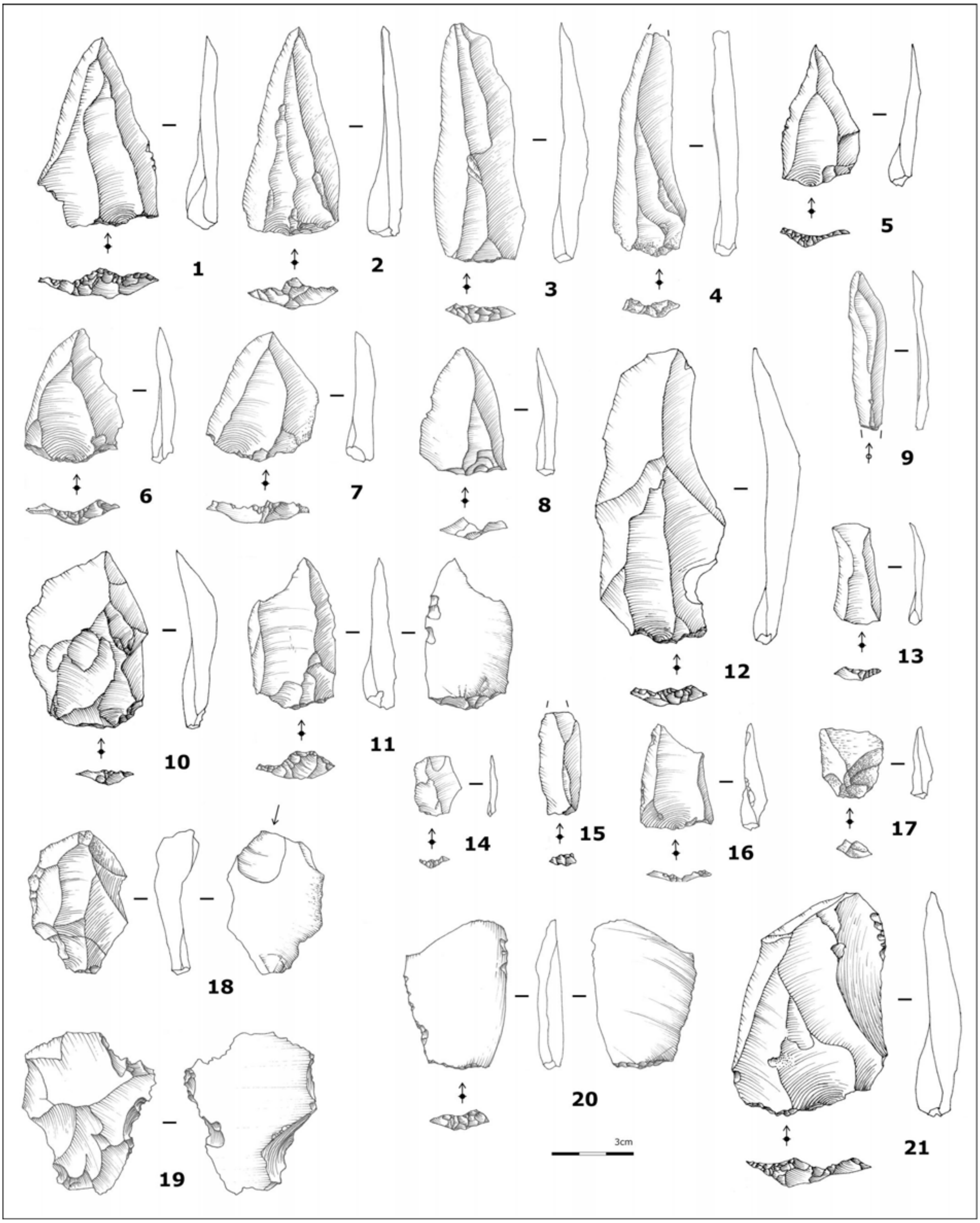


Fig.142: Selected artifacts of assemblage 5b5. Nr.1-2: elongated Levallois points; Nr.2-4: triangular Levallois blades; Nr.5-8: Levallois points; Nr.9: Levallois blade; Nr.10-11; Levallois flakes; Nr.12: plunging Levallois blade; Nr.13: small Levallois blade; Nr.14: small Levallois flake; Nr.15: bladelet; Nr.16: Levallois flake; Nr.17: Levallois-like flake made of limestone; Nr.18: ventral core (Kombewa-type); Nr.19: denticulate; Nr.20: Kombewa flake; Nr.21: partially retouched Levallois flake.

Fig.142

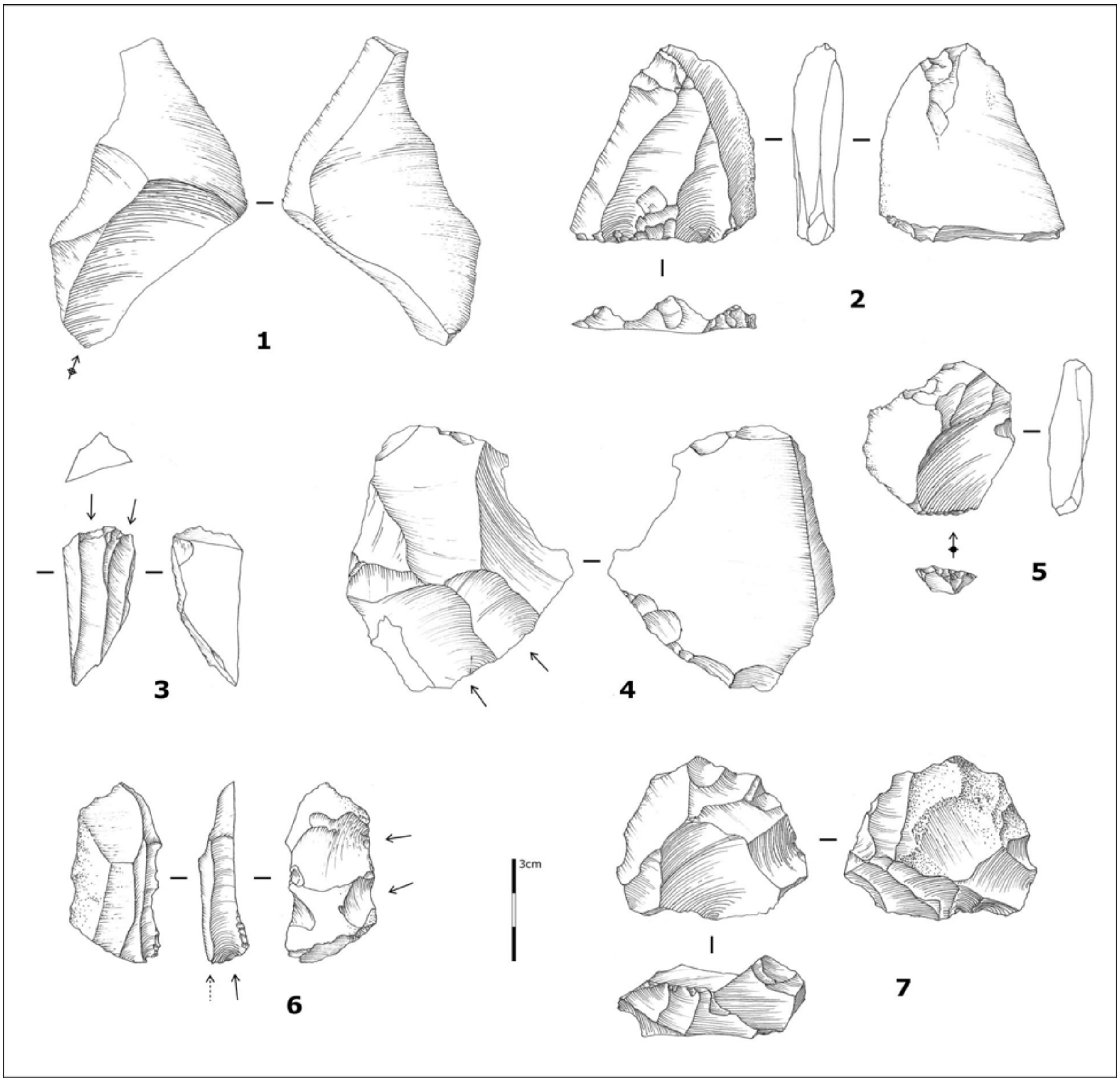


Fig.143: Selected artifacts of assemblage 5b5. Nr.1: Janus flake; Nr.2: recurrent Levallois point core made on flake fragment; Nr.3: non-Levallois bladelet core; Nr.4: core on flake (dorsal type); Nr.5: Janus flake; Nr.6: core on flake (multiple type); Nr.7: preferential Levallois flake core.

Fig.143

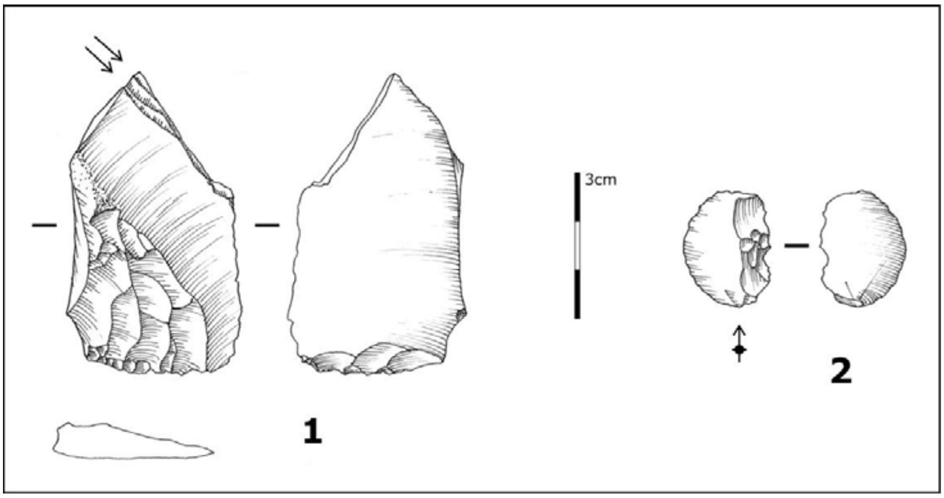


Fig.144: Selected tools of assemblage 5b7. Nr.1: dihedral burin with thinning at the base; Nr.2: small retouched Kombewa flake.

Fig.144

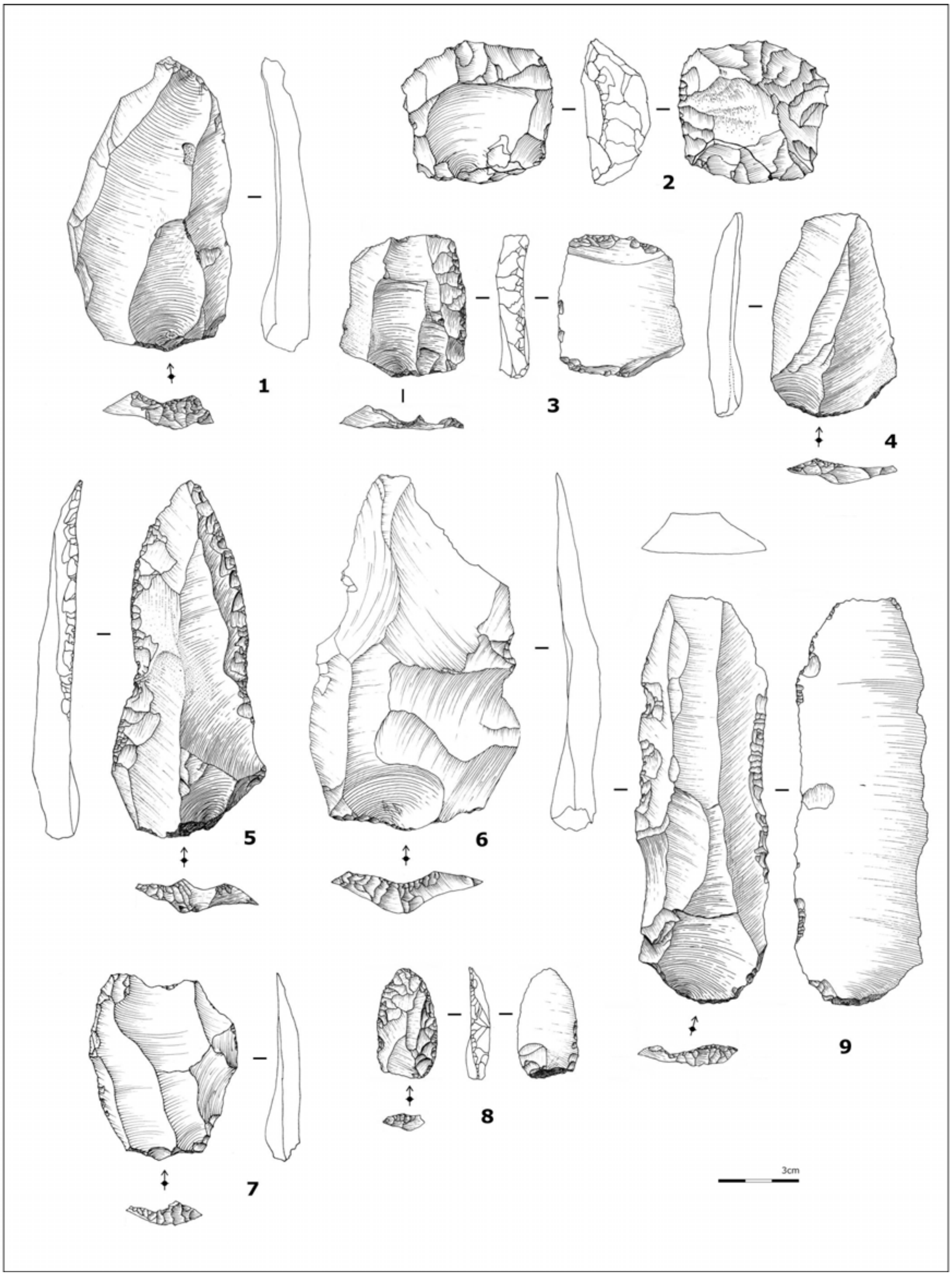


Fig.145: Selected artifacts of assemblages 5e and 5f. Nr.1: Levallois flake with bidirectional scar pattern (level 5e); Nr.2: preferential Levallois flake core (level 5e); Nr.3: core on flake (dorsal type); Nr.4: Levallois flake with bidirectional scar pattern (level 5f2); Nr.5: double convex side scraper (level 5f2); Nr.6: preferential Levallois flake with centripetal scar pattern (level 5f1); Nr.7: Levallois flake with bidirectional scar pattern (level 5f2); Nr.8: covergent convex scraper (level 5f1); Nr.9: alternate retouched side scraper made on Levallois blade with bidirectional scar pattern.

Fig.145

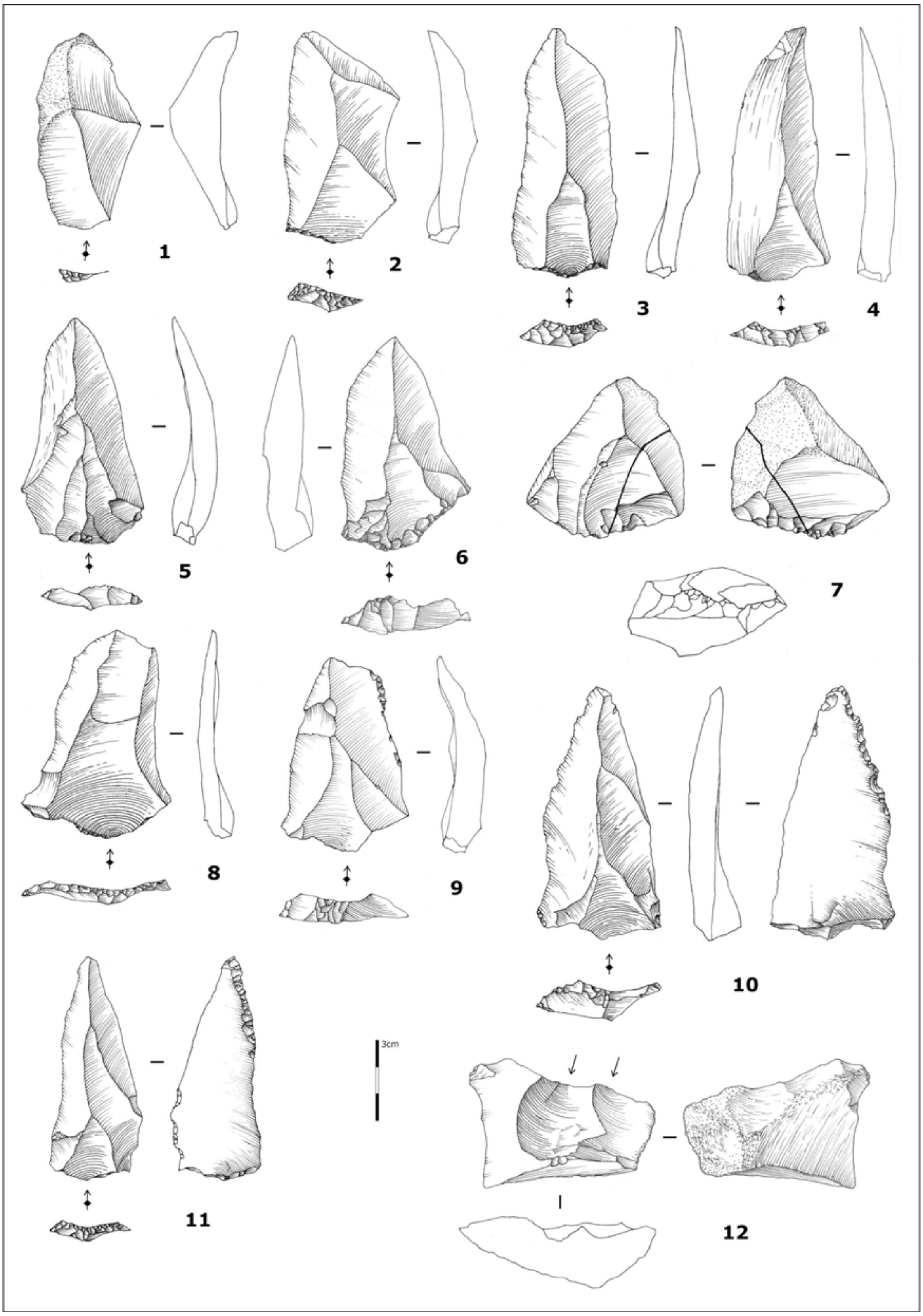


Fig.146: Selected artifacts and retouched tools of assemblage 5AII. Nr.1: naturally backed knife; Nr.2: Levallois flake; Nr.3-6: Levallois points (Nr.4 produced on flake); Nr.7: refitted Levallois point core; Nr.8: Levallois flake; Nr.9: Levallois flake with use wear on right edge; Nr.10-11: Levallois points with retouch on ventral face; Nr.12: core on flake (ventral type).

Fig.146

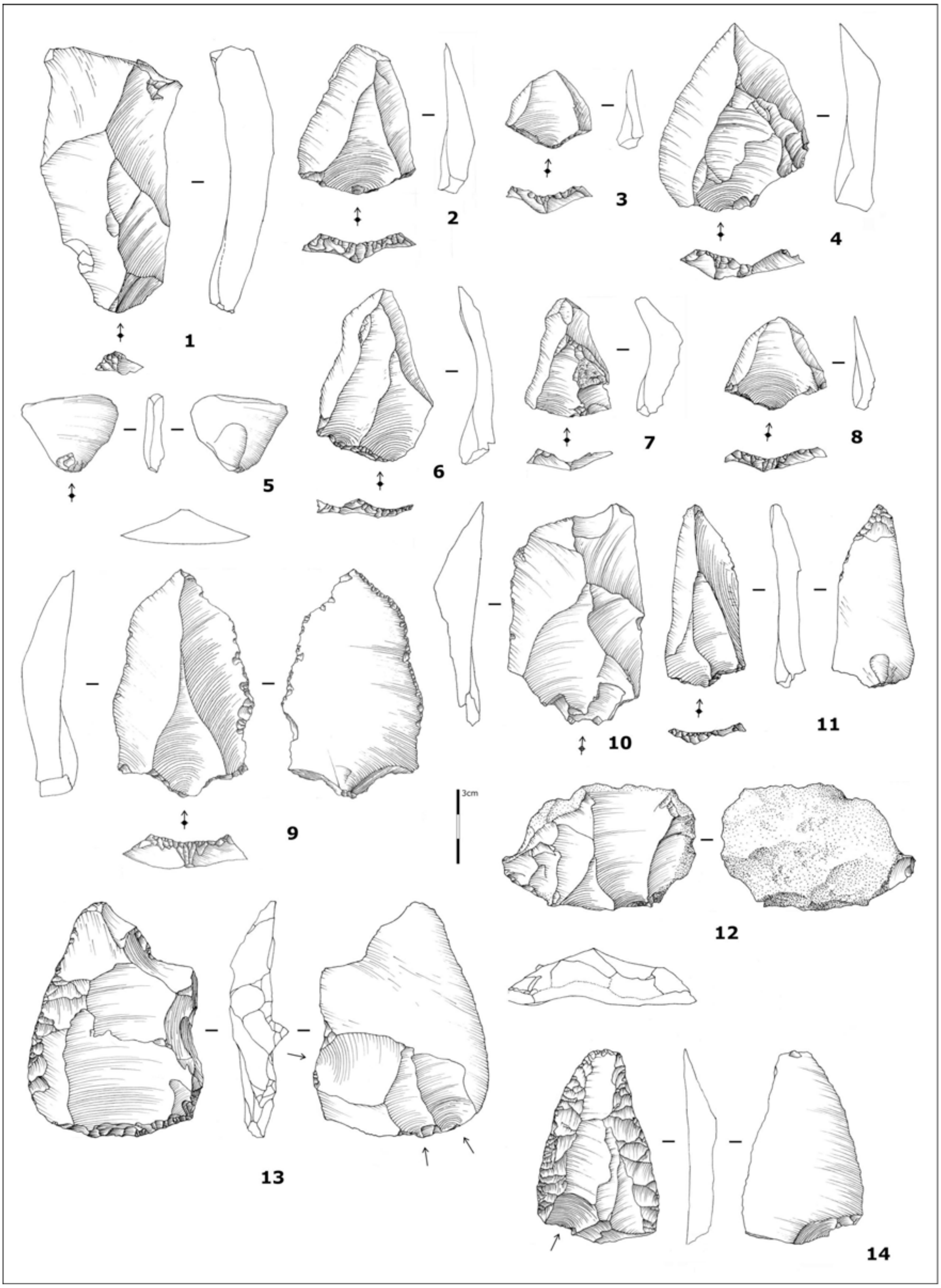


Fig.147: Selected artifacts and retouched tools of assemblage 5AIV. Nr.1: large, plunging core trimming blade; Nr.2-4: broad-based Levallois points; Nr.5: Kombewa flake; Nr. 6: Levallois point; Nr.7: triangular Levallois flake; Nr.8: broad-based Levallois point; Nr.9: Levallois point with ventral retouch at distal tip; Nr.12: recurrent Levallois blade core; Nr.13: core on flake (ventral type) made on large side scraper; Nr.14: core on flake (dorsal type) made on broken double side scraper.

Fig.147

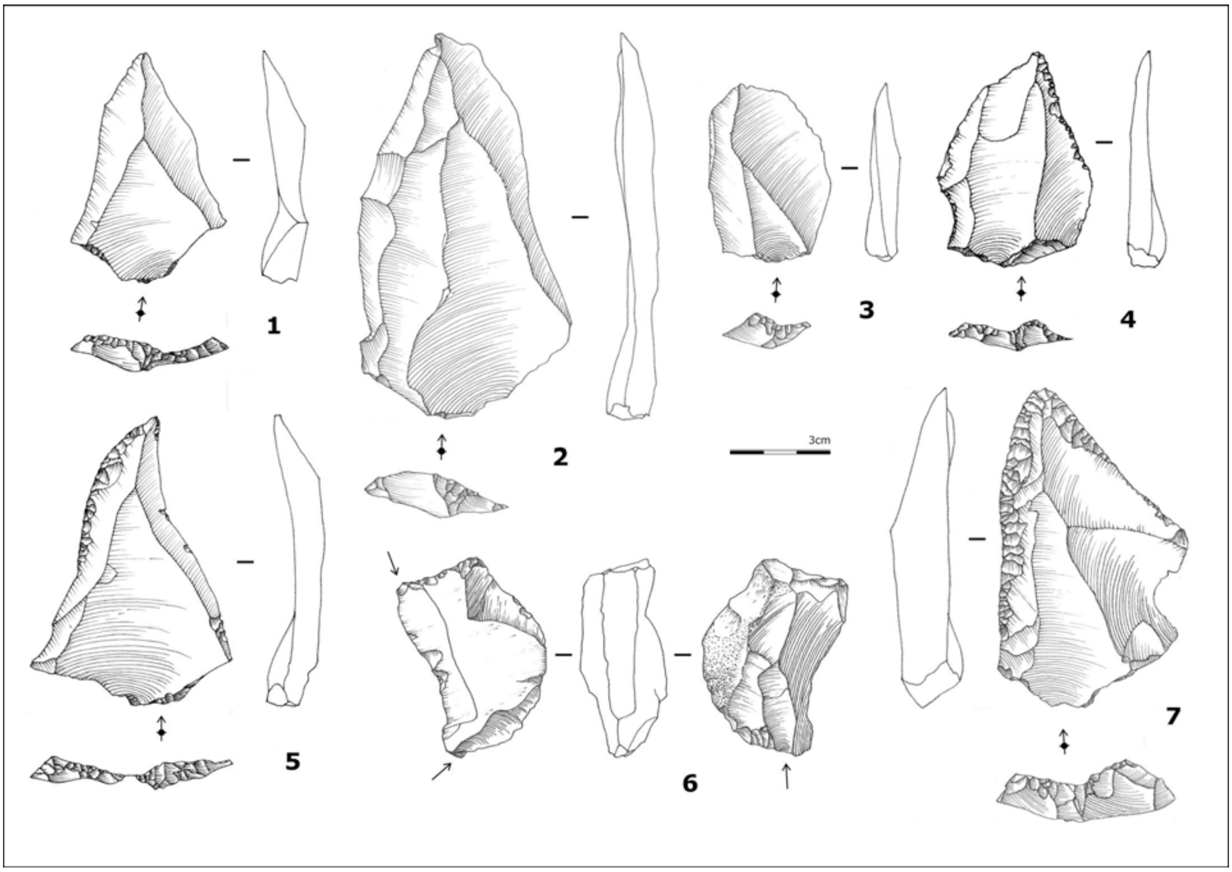


Fig.148: Selected artifacts and retouched tools of assemblage 5AVI. Nr.1-2: broad-based Levallois points; Nr.3: Levallois flake; Nr.4: partially retouched Levallois flake; Nr.5: retouched Levallois point; Nr.6: core on flake (multiple type); Nr.7: convergent scraper made on a large *débordant* Levallois flake.

Fig.148

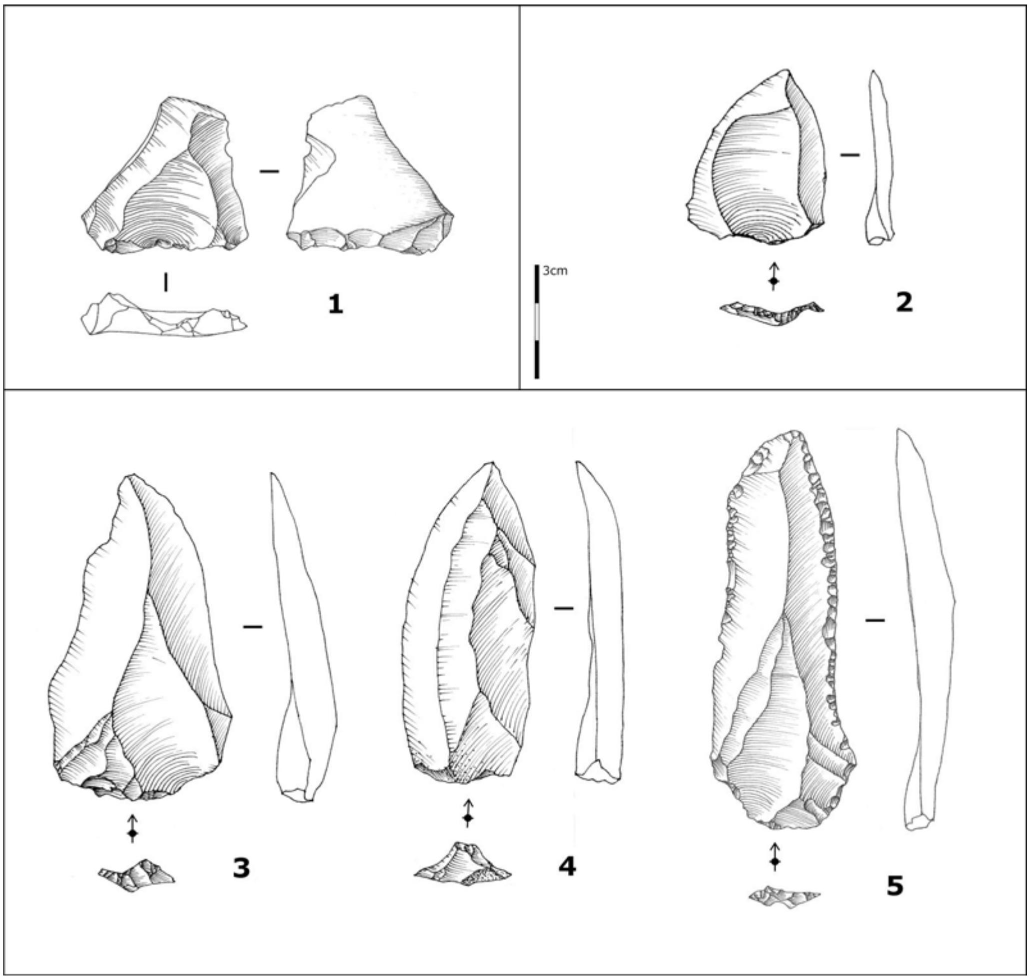


Fig.149: Selected artifacts and retouched tools of assemblages 5BII, 5DIII and 5DV. Nr.1: Levallois point core made on flake (level 5BII); Nr.2: Levallois point (level 5DII); Nr.3-4: elongated Levallois points (level 5DV); double convex side scraper made on Levallois blade (level 5DV).

Fig.149

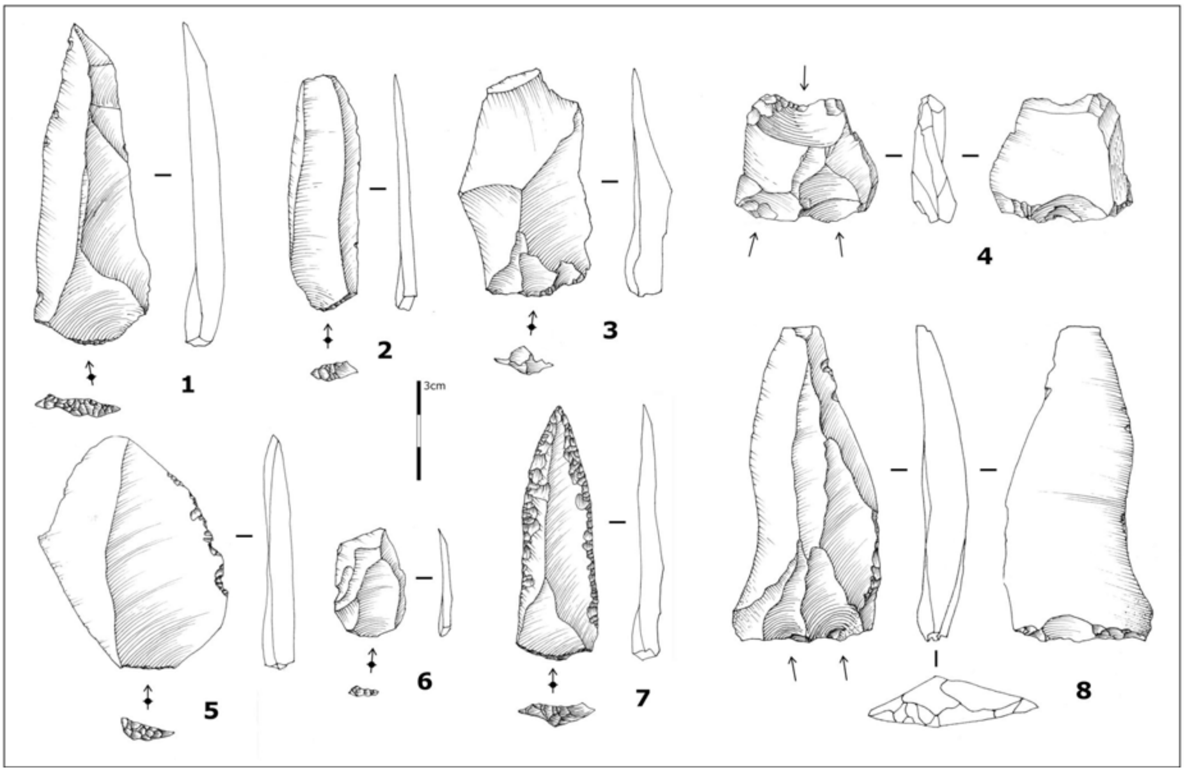


Fig.150: Selected artifacts of assemblage 5E. Nr.1: elongated Levallois point; Nr.2: Levallois blade; Nr.3: Levallois flake; Nr.4: core on flake (dorsal type); Nr.5: Janus flake; Nr. 6: small Levallois flake; Nr.7: elongated Mousterian point; Nr.8: core on flake (dorsal type).

Fig.150

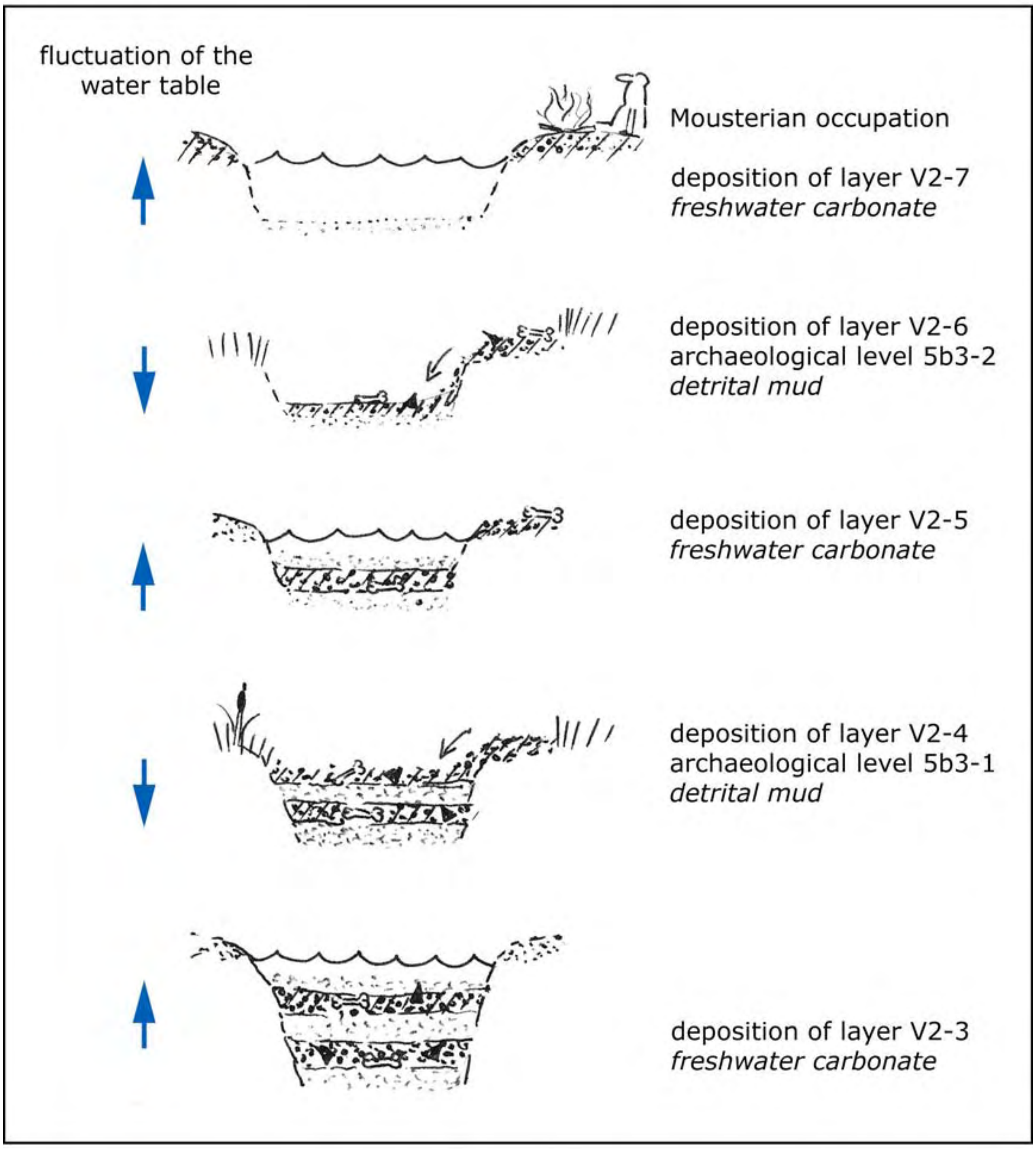


Fig.151: Simplifying model of deposition for archaeological sub-levels 5b3-1 and 5b3-2.

Fig.151

year	results	references	results today
1966-1967	Description of the well as an archaeological site; Mousterian sequence mentioned	Buccelatti et al. 1967 Suzuki et al. 1970	
1978-1980	First examination of Mousterian layers; short description of collected artifacts	Cauvin et al. 1979	Probably a mixture of surface material including Hummalian artefacts
1980-1981	Description of the stratigraphy; Mousterian layers labelled as II, III and IV; short description of the assemblages	Besancon et al. 1981 Besancon et al. 1982	Layers in secondary position, accumulated in the center of the well
1982	First U/Th-dating attempts; no direct dating of Mousterian layers	Hennig et al. 1982	Dates incorrect
1983-1986	Successive revision of the stratigraphy; Hummalian now above Yabrudian; layer VI maybe a transitional culture towards Upper Paleolithic	Le Tensorer 1993 Le Tensorer & Hours 1989	Layer VI is archaeological complex 6 with *in situ* Hummalian
1987-1999	First indications for in situ Mousterian layers in profile P3		Still valid
1999-2002	Detection of the main Mousterian sequence in the Western part of Hummal	Le Tensorer 2004	Assemblage differentiation still valid; stratigraphy revised

Tab.1: Summary of research history until 2003 concerning the Mousterian deposits of Hummal.

Tab.1

year	section	area	size (m²)	archaeological levels	3D artifact measurement
2002	West	test excavation	2	Mousterian levels 5a2, 5a3, 5b1, 5b2, 5b3, 5b4	✔
2003	West	surface A	13	modern and Holocene complexes I to III; Mousterian levels 5a1, 5a2, 5a3	✔
2004	West	trench W1	4	Mousterian levels 5a3, 5b1, 5b2, 5b3, 5b4, 5b5, 5b7, 5d, 5h	-
2005	West	surface A	20	Mousterian levels 5a3, 5a4, 5b1, 5b2, 5b3	✔
	West	surface B	5	Mousterian level 5a3	✔
	West	trench W2	17	none	-
	South	trench S1	11.5	modern and Holocene complexes I to III; Mousterian levels 5AI, 5AII, 5AIII, 5AIV, 5AV, 5AVI, 5BI, 5BII, 5BIII	✔
	South	trench S2	11.5	modern and Holocene complexes I to III; Mousterian levels 5AI, 5AII, 5AIII, 5AIV	✔
2006	West	surface A	13	Mousterian levels 5b3, 5b4, 5b5, 5b6	✔
	West	surface C	7.5	Mousterian levels 5a1, 5a3	✔
	West	trench W2	17	none	-
	West	trench W3	6	Mousterian levels 5b3, 5b4, 5b5, 5c, 5d, 5e, 5f1, 5f2, 5g, 5h	-
	South	trench S1	9	Mousterian levels 5DI, 5DII, 5DIII, 5DIV, 5E, 5FI	✔
2007	West	trench W2	10	none	-
	South	surface D	18	Mousterian levels 5AI, 5AII, 5AIII, 5AIV	✔
	South	trench S1	9	Mousterian levels 5FI, 5FII	✔
	South	trench S3	14	modern and Holocene complexes I to III; Mousterian levels 5AI, 5AII, 5AIII, 5AIV	-
2008	West	trench W2	10	Mousterian level 5a1 (?)	-
	South	surface D	5	Mousterian levels 5AIV, 5AV, 5AVI, 5BI	✔
	South	trench S1	9	Mousterian levels 5FIII, 5FIV, 5FV, 5FVI, 5FVII	✔
	South	trench S3	4	Mousterian levels 5AV, 5BI, 5BII	✔
2009	South	surace D	5	Mousterian levels 5BI, 5BII, 5BIII	✔
	South	trench S3	4	Mousterian levels 5BII, 5BIII	✔

Tab.2: Area and extension of excavation of Mousterian deposits per year. The location of excavation areas is depicted in Fig.8.

Tab.2

complex	layer	sub-layer	archaeological level	sediment type[a]	color	mean thickness	composition	granulometry[b]	particles' sphericity[c]	lithics	faunal remains	micromorphology	sedimentology	profiles
I	1			C?	light gray-brown	53	carbonate clastics; quartz sand; mollusks					no	no	42, 49
	2			C?	7.5R-7/2		carbonate clastics; fine gravel; travertine debris					no	no	42, 49
II	1			GS	light brown	77	littoral carbonates (50%); gypsum (15%); quartz sand (15%); pebbles; charcoal; iron oxides	fs-ms	xx			yes	no	42, 43, 48, 49, 64, 65
	2			GS	dark brown	13	littoral carbonates (35%); gypsum (50%); quartz sand (5%); pebbles; clay pellets	fs-fg	xx			yes	no	42, 43, 48, 49, 64, 65
	3			C	10YR-8/3	11	littoral carbonates (50-60%); gypsum (30%); termite excrements	fs-fg	xx			yes	no	42, 48, 65
	4			GS	10YR-6/4	9	gypsitic sand (>40%)	fs-fg	xx			yes	no	42, 43, 48, 49, 64, 65
	5			C?	light brown	8	unknown					no	no	42
	6			C	10YR-8/3	32	littoral carbonate clastics; gypsum	fs-fg	xx			yes	no	42, 43, 48, 49, 64, 65
III			3	C?	grey	47	carbonate clastics; gypsum; travertine debris; quartz sand; clay pellets; ostracods; iron oxides	cSi-cs	x	+	+	no	yes	42, 43, 48, 49, 64, 65
V	1	1	5a1	LCD	light brown	32	unknown					no	no	48, 49, 64(?), 65(?)
	1	2	5a1	LCD	10YR-8/1	19	carbonatic clay (40%); littoral carbonates (25%); gypsum (10%); quartz sand (10%); organic elements (termite excrements)	fs-ms	xx	+		yes	no	42, 49
	1	3	5a1	LCD	5Y-8/2	57	carbonatic clay; littoral carbonates (5%); gypsum (10%); quartz sand (5%);	fs-ms	xx	+		yes	no	42, 43, 48, 49, 64(?), 65(?)
	1	4		C?	light brown	?	travertine debris in fine-grained matrix	fs-cg				no	no	48, 49, 54, 60, 65
	1	5	5a2	LCD?	not recorded	3	carbonatic silt; clay; organic remains			+	+	no	no	28, 29, 42-1, 53
	1	6	5a3	K	light brown	10	littoral carbonates (60-70%); quartz sand; limnic elements; organic remains	fs	xx	+	+	yes	no	28, 29, 42-1 50, 53
	1	7	5a3	LCD	green-brown	27	carbonates (10-30%); calcareous cements; gypsum; clay; quartz sand; organic elements; iron oxides	fs-fg	xx	+	+	yes	no	28, 29, 42-1 50, 53
	1	8	5a3	K	light brown	15	carbonates; gypsum; quartz sand; liminic elements; *Characea*	fSi-cSi	xx	+	+	yes	no	50, 53, 66
	1	9	5a4	LCD	green-brown	6	carbonates; clay			+	+	no	no	50, 53
	2	1	5b1	LL	light grey-white	24	carbonates (70%); gypsum (5%); quartz sand (5%); limnic elements; Characea	fs	xx	+	+	yes	yes	28, 29, 44, 45, 50, 53 (?)
	2	2	5b2	AV	olive green	6	carbonates (30-40%); gypsum (10-15%); clay (1%); quartz sand (2%); limnic elements; organic elements; iron oxides	fs-ms	-	+	+	yes	no	44, 45, 50
	2	3	5b2	LL	light grey-white	6	carbonates (5-10%); gypsum (5-10%); quartz sand (5%); limnic elements; organic elements; iron oxides	fs-ms	-	+	+	yes	no	44, 45, 50, 51, 52, 53
	2	4	5b3-1	LCD	light grey	17	carbonates (30-40%); gypsum (10-20%); quartz sand (5%); travertine debris organic elements (1%)	fs	x	+	+	yes	yes	44, 45, 50, 51, 52, 53
	2	5		K	light grey-white	30	carbonates (70-80%); gypsum (5-10%); quartz sand (2%); limnic elements	fs	-			yes	no	50, 53
	2	6	5b3-2	LCD	light grey	20	carbonates; gypsum; quartz sand; travertine debris; liminic elements	fs-ms	x	+	+	no	yes	44, 45, 50, 52(?), 53
	2	7	5b4	LC?	light grey-white	16	unknown			+	+	no	no	44, 45
	2	8		AV?	olive green		unknown			+		no	no	4(?), 6(?), 44, 45
	2	9		LC?	light grey-white		unknown			+		no	no	4(?), 6(?), 44, 45
	2	10	5b5	LCD	light grey	13	carbonates; gypsum; quartz sand; travertine debris; organic elements		xx	+	+	no	yes	44, 45, 52
	2	11	5b6	LC?	light grey-white	5	unknown					no	no	44, 45, 52
	2	12	5b7	LCD	light grey	16	carbonates; gypsum; quartz sand; travertine debris; organic elements		x	+	+	no	yes	44, 45, 52

(continued)

Tab.3

complex	layer	sub-layer	archaeological level	sediment type[a]	color	mean thickness	composition	granulometry[b]	particles' sphericity[c]	lithics	faunal remains	micromorphology	sedimentology	profiles
V	2	13		C?	light brown	30	unknown					no	no	4, 6
	3	1	5d	AV?	olive green	35	unknown			+	+	no	no	4, 6
	3	2		C?	light brown		unknown					no	no	4, 6, 44(?), 45(?), 51(?), 52(?)
	4	1	5e	AV	dark green	15	clay; gypsum			+		no	no	4, 6, 51, 52
	4	2		AV	olive green	10	carbonate clastics; gypsum; clay; calcified plant remains			+		no	no	4, 6, 51, 52
	4	3		AV	olive green	7	carbonate clastics; gypsum; clay; calcified plant remains			+		no	no	4, 6, 51, 52
	5	1	5f1	AV	dark green-brown	8	carbonate clastics; gypsum; clay	cSi-fg	x	+	+	no	yes	4, 6, 51, 52
	5	2		C?	light brown	20	unknown			?	?	no	no	4, 6
	5	3	5f2	C	olive green	20	carbonate clastics; gypsum; travertine debris; iron oxides			+	+	no	no	4, 6, 51, 52
	5	4	5f3	C	light brown	19	carbonates (40-60%); quartz sand (5-10%); gypsum; travertine debris; limnic elements; iron oxides	fs-fg	xx		+	yes	no	4, 6, 51, 52
	6	1	5g	EC	orange-brown	11	carbonates (60-90%); quartz sand (5-20%); gypsum; iron oxides; organic elements; calcified plant remains	fs-mg	xx	+		yes	yes	4, 6, 51
	6	2		C	orange-brown		carbonates (50-60%); quartz sand (15-20%); iron oxides; organic elements	fs-cg	xx	+		yes	no	4, 6
	7	1		LCD?	light brown	15	unknown					no	no	51, 52
	7	2		AV	olive green	7	carbonate clastics; quartz sand (10%); clay; gypsum; gastropods	cSi-fg	x			no	yes	27(?), 51, 52
	7	3		LCD?	light grey-green	20	carbonate clastics; gypsum; travertine debris					no	no	27(?), 51, 52
	7	4		AV	olive green	20	carbonate clastics; quartz sand (10%); clay; gypsum					no	no	27(?), 44, 45, 51, 52
	8	1		C	light grey-white	176	carbonates (5-90%); quartz sand (1-10%); gypsum; iron oxides; organic elements	cSi-fs	xx			yes	no	3, 4, 6, 7, 44, 45, 51, 52
	8	2	5h	LCD	light grey-white		carbonates (20-40%); quartz sand (2-5%); gypsum; iron oxides; limnic elements	fs-cs	xx	+	+	yes	no	3, 7

[a] **sediment types (as defined by Rentzel 1998 and Meyer 2001)**

AV = green colored clay
C = colluvium
EC = sediment consisting primarily of clastics
GS = gypsitic sand
K = freshwater carbonate
LCD = detrital carbonate mud
LL = laminated carbonate mud

[b]**granulometric fractions** (after data recorded by K. Ismail-Meyer (2001) and A.-S. Martineau):

cg = coarse gravel (20-63mm)
mg = medium gravel (6.3-20mm)
fg = fine gravel (2.6-3mm)
cs = coarse sand (0.6-2mm)
ms = medium sand (0.2-0.6mm)
fs = fine sand (0.06-0.2mm)
cSi = coarse silt (20-60µm)
mSi = medium silt (6-20µm)
fSi = fine silt (2-6µm)

[c]**rounding of carbonate and quartz particles**

well rounded (xx)
slightly rounded (x)
angular (-)

Tab.3: list of all identified deposits in the western sequence

Tab.3

complex	layer	sub-layer	archaeological level	sediment type[a]	color	mean thickness	composition	granulometry[b]	particles' sphericity[c]	lithics	faunal remains	micromorphology	sedimentology	profiles
I				C	grey-brown	180	backdirt (well construction, excavation)					no	no	58, 59, 71
II	1			CC	light brown-yellow	8	calcite					no	no	58, 59, 71
	2			GS	light brown	50	carbonate clastics; gypsum; quartz sand	fs-ms	x			no	yes	58. 59, 69, 71
III				C?	grey-brown	31	carbonate clastics; gypsum; quartz sand; iron oxides	cSi-cs	x			no	yes	58. 59, 69, 71
V	1	1	5AI	LC?	light brown	27	carbonatic silt			+		no	no	69, 71
	1	2	5AI	AV?	olive green	9	carbonates; gypsum; clay			?		no	no	69, 71
	1	3-1	5AI	LC?	light brown	31	carbonates; gypsum			+	+	no	no	58, 59, 69, 71
	1	3-2	5AI	AV?	olive green	10	carbonates; gypsum; clay			?	?	no	no	69, 71
	1	4	5AI	LC	light brown	10	carbonates; gypsum	Si-s	x	+	+	no	yes	58, 59, 63, 69, 71, 72
	1	5	5AII	LCD	light grey-green	24	carbonate clastics; gypsum; clay; organic material; iron oxides; manganese; gastropods	Si-s	xx	+	+	no	yes	58, 59, 63, 68, 69, 70a, 71, 72
	1	6-1	5AIII	LCD	light brown	20	carbonate clastics; iron oxides; manganese			+		no	no	58, 59, 63, 68, 69, 70, 71, 72
	1	6-2	5AIII	LCD	light grey-brown	25	carbonate clastics; quartz sand; travertine clastics iron oxides; manganese	Si-fg	x	+		no	yes	58, 59, 63, 68, 69, 70, 71, 72
	1	6-3	5AIII	LCD	light brown	5	carbonate clastics; iron oxides; manganese			+		no	no	58, 59, 63, 68, 69, 70, 71, 72
	1	7	5AIV	AV?	olive green	7	carbonate clastics; quartz sand; gypsum; clay	s	xx	+	+	no	yes	58, 59, 63, 68, 69, 70b, 71, 72
	1	8	5AV	LCD	light brown-green	31	carbonate clastics; gypsum; iron oxides; manganese	Si-fg	xx	+		no	yes	58, 59, 63, 68, 69, 70b, 71, 75
	1	9		AV?	olive green	10	unkown			?	?	no	no	71
	1	10		LCD?	light brown	20	unkown			?	?	no	no	71
	1	11	5AVI	LCD	light brown-grey	34	carbonates; travertine			+	+	no	no	58, 59, 63, 71, 75
	2	1	5BI	LCD	light brown-white	11	carbonate clastics; quartz sand; gypsum; gastropods	s	x	+	+	no	yes	58, 59, 63, 68, 69, 70b, 71, 75
	2	2	5BII	LCD	light grey	17	carbonate clastics; quartz sand; gastropods; ostracods; iron oxides; *Characea*	s	xx	+	+	no	yes	58, 59, 63, 68, 69, 70b, 71, 75
	2	3	5BIII	LCD	grey-orange	17	carbonate clastics; algal tufa; quartz sand; iron oxides; gastropods; ostracods; *Characea*	Si-fg	x	+	+	no	yes	58, 59, 63, 71, 75
	3	1		LC	light brown-white	27	micrite					no	no	58, 59, 63
	3	2	5DII	LCD?	light brown-white	2	carbonate clastics; clay			+	+	no	no	58, 59, 63
	3	3-1	5DIII	LCD	light brown	10	carbonate clastics; detritus			+	+	no	no	58, 59, 63
	3	3-2	5DIII	LC	light brown		micrite			+	+	no	no	58, 59, 63
	3	3-3	5DIII	LCD	light brown		carbonate clastics; detritus			+	+	no	no	58, 59, 63
	3	4	5DIV	LL	light brown	24	carbonates (50-80%); gypsum (1%); quartz sand (5%); clay pellets; gastropods; ostracods; *Characea* ; organic material (10-20%)			+		yes	no	58, 59, 63
	3	5	5DV	LL	light brown	3	carbonates (60-90%); gypsum (<1%); quartz sand (2-20%); clay pellets; iron oxides; gastropods; ostracods; oogones; foraminifera; *Characea* ; organic remains (1-5%)		x	+	+	yes	no	58, 59, 63
	4	1	5E	LS	orange-brown	3	carbonates (60-70%); quartz sand (10%); iron oxides; gastropods; foraminifera; *Chatacea* ; oogones; organic remains (1%)	Si-fg	x	+	+	yes	yes	58, 59, 63

(continued)

Tab.4

complex	layer	sub-layer	archaeological level	sediment type[a]	color	mean thickness	composition	granulometry[b]	particles' sphericity[c]	lithics	faunal remains	micromorphology	sedimentology	profiles
V	4	2	5E	LL	light brown	9	carbonates (90%); quartz sand (5%); gypsum; iron oxides; gastropods; ostracods; *Characea*; oogones; foraminifera; organic remains (1%)			+	+	yes	yes	58, 59, 63
	4	3	5E	LS	orange-brown	8	carbonates (40-70%); quartz sand (10-20%); gypsum (2%); iron oxides; gastropods; ostracods; foraminifera; organic remains (1%)	Si-fg	xx	+	+	yes	yes	58, 59, 63
	5	1	5FI	AN	dark brown-black	10	carbonates (40-70%); quartz sand (5-30%); gypsum; iron oxides; gastropods; ostracods; organic remains (5-20%)		x	+	+	yes	yes	58, 59, 63
	5	2	5FII	LC	grey-green	30	carbonates (30-90%); quartzs sand (1-10%); gypsum (0-20%); iron oxides; ostracods; foraminifera; organic remains (1%)	Si	xx	+	+	yes	yes	58, 59, 63
	5	3		LCD	grey	14	carbonate clastics; gypsum; iron oxides; gastropods; ostracods	Si-s	x			no	yes	58, 59, 63
	5	4	5FIV	LC	grey-brown	25	unknown			+	+	no	no	58, 59, 63
	5	5	5FV	AV	light grey-green	15	carbonate clastics; quartz sand; gypsum; *Characea*	Si-s	-	+	+	no	yes	58, 59, 63
	5	6	5FVI	LC	grey	55	carbonate clastics; gypsum; gastropods	s	xx	+	+	no	yes	58, 59, 63
	5	7	5FVII	AN	dark brown-black	30	carbonate clastics; quartz sand; clay; gastropods; ostracods	Si-s	xx	+	+	no	yes	58, 59, 63

[a] **sediment types** (as defined by Meyer 2001)

AV = green colored clay

C = colluvium

EC = sediment consisting primarily of clastics

GS = gypsitic sand

K = freshwater carbonate

LCD = detrital carbonate mud

LL = laminated carbonate mud

LS = littoral sands

[b] **granulometric fractions** (after data recorded by K. Ismail-Meyer (2001) and A.-S. Martineau):

cg = coarse gravel (20-63mm)

mg = medium gravel (6.3-20mm)

fg = fine gravel (2.6-3mm)

cs = coarse sand (0.6-2mm)

ms = medium sand (0.2-0.6mm)

fs = fine sand (0.06-0.2mm)

cSi = coarse silt (20-60µm)

mSi = medium silt (6-20µm)

fSi = fine silt (2-6µm)

[c] **rounding of carbonate and quartz particles**

well rounded (xx)

slightly rounded (x)

angular (-)

Tab.4: list of all identified deposits in the southern sequence

Tab.4

Tab.5

level	sediment	mean thickness (cm)	surface excavated	find density (m^3)	fauna		lithics			
					N	preservation	N	sample	patination	edge damage
5a1	colluviated carbonatic silts	?	11	?	1	poor	684	mixed	variable	not analyzed
5a2	detrital carbonate mud	20	11	2965.5	no preservation		1631	homogeneous	weak	6%
5a3	detrital carbonate mud	30	36.5	173.8	268	poor	1436	homogeneous	weak	8%
5a4	detrital carbonate mud	6	8	2319.7	75	poor	1044	homogeneous	weak	8%
5b1	laminated carbonate mud	20	10	173.5	45	good	363	homogeneous	no	14%
5b2	detrital carbonate mud	6	20	564.2	78	poor	599	homogeneous	weak	5%
5b3	detrital carbonate mud	30	20	660.9	325	good	1916	homogeneous	weak	19%
5b4	gypsitic clay	2	3	170.8	23	good	59	homogeneous	weak	-
5b5	detrital carbonate mud	35	20	289.2	53	good	714	homogeneous	weak (4% de-dolomitized)	8%
5b6	gypsitic clay	not fully excavated			3	?	28	homogeneous	strong	1%
5b7	detrital carbonate mud	20	3	803.3	34	good	448	homogeneous	weak	not analyzed
5c	no data	15	3	?	2	?	4	homogeneous	strong	not analyzed
5d	no data; colluvium in trench W1	10	3	?		?	12	homogeneous	strong	not analyzed
5e	gypsitic clay	30	6	73.4	1	poor	140	homogeneous	strong	2% (trampling)
5f1	gypsitic clay	8	6	408.3	1	poor	195	homogeneous	strong	2% (trampling)
5f2/3	gypsitic clay	20	6	162.5	2	poor	193	homogeneous	strong	1% (trampling)
5g	carbonate clastics, sand	11	6	100	4	poor	62	mixed	strong, variable	1% (trampling)
5h	colluviated carbonatic silts	180	> 10		not examined yet			mixed	?	not analyzed

Tab.5: Archaeological parameters of the western Mousterian sequence.

Tab.6

level	sediment	mean thickness (cm)	surface excavated	find density (m^3)	fauna		lithics			
					N	preservation	N	sample	patination	edge damage
5AI	detrital carbonates / gypsitic clay	111	39	1.0	no preservation		42	homogeneous	strong	?
5AII	detrital carbonate mud	24	53	24.8	1	poor	315	homogeneous	strong	3%
5AIII	detrital carbonate mud	46	53	4.7	no preservation		114	homogeneous	strong	1%
5AIV	gypsitic clay	7	53	264.7	8	poor	982	homogeneous	strong	8%
5AV	detrital carbonate mud	31	18	57.9	3	poor	323	homogeneous	strong	1%
5AVI	detrital carbonate mud/travertine	24	10	24.7	10	good	84	homogeneous	weak	2%
5BI	detrital carbonate mud	11	17.5	72.2	46	good	93	homogeneous	weak	1%
5BII	detrital carbonate mud/travertine	17	17.5	151.9	77	poor	375	homogeneous	weak	6%
5BIII	detrital carbonate mud/travertine	17	17.5	68.2	49	poor	154	homogeneous	weak	-
5DII	detrital carbonate mud	2	6	25.0	1	?	2	?	?	?
5DIII	freshwater carbonate	10	6	15.0	4	?	5	?	?	?
5DIV	laminated carbonate mud	24	6	2.1	0	?	3	?	?	?
5DV	laminated carbonate mud	3	6	411.1	19	good	55	homogeneous	no	2%
5E	littoral sands	20	6	265.0	75	good	243	homogeneous	no	8%
5FI	clay	10	6	30.0	6	poor	12	mixed	variable	100% (trampling)
5FII	freshwater carbonate	30	6	7.8	4	poor	10	mixed	variable	100% (trampling)
5FIV	freshwater carbonate	25	6	7.3	3	poor	8	mixed	variable	100% (trampling)
5FV	clay	15	6	5.6	1	poor	4	mixed	variable	100% (trampling)
5FVI	freshwater carbonate	55	6	23.0	54	poor	22	mixed	variable	100% (trampling)
5FVII	clay	30	6	2.8	3	poor	2	mixed	variable	100% (trampling)

Tab.6: Archaeological parameters of the southern Mousterian sequence.

Tab.7

	analyzed	Aves		Bovidae		Camelidae		Equidae		Gazellinae		Homo sp.		Strutio		Suidae		indet	
	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
5AIV	2					1	50.0%											1	50.0%
5AVI	2																	2	100.0%
5a1	1									1	100.0%								
5a3	89			1	1.1%	27	30.3%	2	2.2%	5	5.6%							54	60.7%
5a4	29			1	3.4%	10	34.5%			1	3.4%	1	3.4%					16	55.2%
5b1	55	1	1.8%	1	1.8%	21	38.2%	4	7.3%	6	10.9%	1	1.8%	1	1.8%	1	1.8%	19	34.5%
5BI	3							1	33.3%									2	66.7%
5b2	38			3	7.9%	17	44.7%			1	2.6%							17	44.7%
5BII	19					3	15.8%	3	15.8%									13	68.4%
5b3	184					69	37.5%	5	2.7%	11	6.0%							99	53.8%
5BIII	49					5	10.2%	4	8.2%	2	4.1%							38	77.6%
5b4	13					2	15.4%	3	23.1%									8	61.5%
5b5	53					17	32.1%	1	1.9%	2	3.8%							33	62.3%
5b6	2									1	50.0%							1	50.0%
5b7	22					9	40.9%	1	4.5%	4	18.2%							8	36.4%
5c	2																	2	100.0%
5DII	1					1	100.0%												
5DIII	2																	2	100.0%
5DV	19					6	31.6%			2	10.5%							11	57.9%
5E	75					21	28.0%	3	4.0%	4	5.3%			1	1.3%			46	61.3%
5f2	1							1	100.0%										
5f3	1									1	100.0%								
5g	4					4	100.0%												
5h	1					1	100.0%												
total	**667**	**1**	**0.1%**	**6**	**1.0%**	**214**	**32.5%**	**28**	**4.2%**	**41**	**6.0%**	**2**	**0.3%**	**2**	**0.3%**	**1**	**0.1%**	**372**	**55.5%**

Tab.7: Frequency of identified and unidentified faunal remains according to genus (analysis: P.Schmid).

	counts	Vertebrae	Long bones	Carpals & tarsals	Phalanges	Cranial	Dentes
Camelidae	366	46	180	52	16	27	45
Bovidae	61	0	5	1	3	42	10
Equidae	66	2	10	5	2	1	46

Tab.8: Body part representation of major ungulate species found in the Hummal Mousterian (all assemblages grouped; analysis: P. Schmid).

Tab.9

industry	assemblages	blanks						core trimming elements								fragments			cores									
		Levallois flakes	Levallois blades	Levallois points	Non-Levallois blades	Non-Levallois flakes	Kombewa / Janus flakes	cortical flakes	core tablets	striking platform flakes	core edge flakes	flaking surface flakes	core trimming s.l.	indeterminable	*% retouched*	Levallois fragments	fragments	tool fragments	Levallois cores	flake cores	cores on flakes	core indet	core fragments	pebble tools	pebbles	chips (<2cm)	total	total (excl. chips)
HM-A1	**5AI**		1														2			1						37	**42**	**5**
	5AII	14	19	12	2	4	2	7		7	20	16	6		*16*	7	15	1	1		2					177	**315**	**138**
	5AIII	2	2	3		1						4	2		*21*	8	28			2	1	1				56	**114**	**58**
	5AIV	57	32	49	2	1	5	20	2	16	13	45	16	2	*11*	33	60	3	2	3	9					532	**916**	**384**
	5AV	3	1	4				2			1	4	3	1	*11*	3	5	2	2	2	2					260	**301**	**41**
	5AVI	16	9	4				2			3	9	2		*24*	3	6	2		3	3				1	2	**71**	**69**
HM-A2	**5a1**	40	30	23	3		4	29			185				*3*	5	289		5	13	16		4				**684**	**684**
	5a2	31	23	21	2	1	8	36		34	24	91	72	4	*10*	26	170	2	3	4	10	1	1	1		1047	**1631**	**584**
	5a3	23	27	24	10	2	3	33	2	23	20	49	82	6	*10*	37	123	8	4	2	14	1	1	2		918	**1436**	**518**
	5a4	13	12	9	2			9	1	8	13	32	31	2	*17*	20	94	3	2	5	3					775	**1044**	**269**
	5b1	9	8		2	1		4		3	2	6	21		*16*	4	28	6	1	1	4			1		256	**363**	**107**
	5BI	1	1	1							1	4	1		*22*												**9**	**9**
	5b2	11	3	9	1	2	2	10	1	3	6	15	18		*14*	10	35	9	1	2	4					450	**599**	**149**
	5BII	14	14	6		3	1	3		1	4	19	9	1	*9*	1	5		2		2						**89**	**89**
	5b3	53	51	32	7	6	2	37	4	39	28	70	127	6	*10*	31	118	12	4	16	8					1237	**1916**	**679**
	5BIII						1									7	13	2		1	6		1				**39**	**39**
	5b4	2	3	2				1					14	1	*4*	4	9	3								20	**59**	**39**
	5b5	28	21	7		2	6	19		12	14	22	22	5	*7*	32	109	3	2	6	11	2			1	369	**714**	**345**
	5b6	1	2	1		1				1	1	3	4		*14*	1	11						1				**28**	**28**
	5b7	8	7	6		1	1	5		2		3	15	1	*10*	9	39		1	1	2		1			341	**448**	**107**
	5c	1															2	1									**4**	**13**

(continued)

Tab.9

industry	assemblages	Levallois flakes	Levallois blades	Levallois points	Non-Levallois blades	Non-Levallois flakes	Kombewa / Janus flakes	cortical flakes	core tablets	striking platform flakes	core edge flakes	flaking surface flakes	core trimming s.l.	indeterminable	*% retouched*	Levallois fragments	fragments	tool fragments	Levallois cores	flake cores	cores on flakes	core indet	core fragments	pebble tools	pebbles	chips (<2cm)	total	total (excl. chips)
HM-A2	**5d**	1	1	2							1	1	1			1	3	1									**12**	**12**
HM-A2	**5DII**			1								1															**2**	**2**
HM-A2	**5DIII**											1					2					1					**5**	**5**
HM-A2	**5DIV**																1						1				**3**	**3**
HM-A2	**5DV**	1	5	3			1	3			2	7	3		*8*	7	9				4	1				4	**55**	**51**
HM-A2	**5E**	16	22	12			4	7	2	4	5	33	15		*11*	24	43	1	1	1	9				1	31	**242**	**211**
HM-B	**5e**	4	3	2			1	1			4	5	5		*16*	10	14	4	2		2				1	78	**140**	**62**
HM-B	**5f1**	6	5	1	1		2	3	1	3	2	1	4	1	*23*	7	5	1			1					150	**195**	**45**
HM-B	**5f2/3**	7	9	1	1		1	2				2			*39*	6	6	2			3					150	**193**	**43**
HM-B	**5g**	5	5	1				5		1	3	2	3		*16*	8	14	1								14	**62**	**48**
Artifacts retrieved from test trenches / sedimentological units:																												
HM-A2	**5a (profiles)**	16	16	11	1	2	2	8	1	5	14	19	4	3	*19*	18	32	8	2	4	5		2				**186**	**186**
HM-A2	**5aIII_West**	3						2		3		3	2			3	10	1								280	**307**	**27**
HM-A2	**5b (profiles)**	10	10	5	2	1		4		3	1	2	11	1	*14*	3	1	3			3						**63**	**63**
HM-A2	**5b1+2 (trench W1)**	5	2	5				1		1		6	3		*9*	1	13			2	2					99	**144**	**45**
HM-A2	**5b5 (trench W1)**	6	4	2		1		5		1		12	1	1	*6*	6	33	2	2	5	2					305	**397**	**92**
HM-A2	**5b7 (trench W1)**	2	1	1				5		1		5	3			2	13				1					87	**122**	**35**
HM-A2	**5b3-7 (trench W3)**	9	12	9		1		2					9			9	18			3	3					116	**197**	**81**
HM-A2/HM-B	**5d-f (trench W1)**	4	6		10	5		4				1	12		*33*	7	42	1	1	4						211	**313**	**102**
HM-B	**5f (trench W3)**	2														1	3					1					**8**	**8**
?	**5E/F (trench S1)**										1	1	1				1				1						**6**	**6**
?	**5FI (trench S1)**	1		1				2									1				1						**7**	**7**
?	**alpha-m (2000)**	7	19	28	2			99						4	*13*			8			8			2		79	**264**	**185**
?	**alpha-m (D28-29)**	47	77	83				19							*39*	44		5	5	20				1		70	**396**	**326**
?	**alpha-m (B26-C27)**		-- 436 --		6										*54*	-- 429 --			-- 57 --		11			3	2	>1000	**>2000**	

Tab.9: Total artifact sample recovered in single archaeological levels and test trench units (the 2008 and 2009 samples are not analyzed yet and therefore not included).

	attribute	features
1	signature / year	*HU....*
2	n° of piece	
3	section of excavation	West, South, East, West
4	level	eg. "5a"
5	sub-level	eg. "3"
6	square / trench	
7	patination	none; black-dark grey; light grey; brown; yellow; white; glossy; corrosion
8	double patination	
9	raw material	Eocene flint; Cretacious flint; limestone; travertine; de-dolomitized; indeterminable
10	traces of heating	yes / no
11	amount of cortex	0%, 10%,...,100%
12	cortex type	none; fresh; below surface; weathered; neocortex; cortex & neocortex
13	damage	none; old; modern; both

Tab.10: General attributes recorded for complete flakes, cores and fragments.

Tab.10

	attribute	features
1	object category	flake; blade; point
2	morphology	triangular; quadrangular; rounded / oval; polygonal; conic / tetrahedral; polyhedral; irregular
3	use wear	yes / no
4	location of cortex	examination of sectors according to Fig. 57, Nr.2
5	location of edge damage	dorsal and ventral face: examination of sectors according to Fig. 57, Nr.2
6	butt preparation	faceted; faceted cortex; dihedral; plain; cortex; cortex & faceting; splintered; indeterminable
7	butt morphology	rhomboid; trapezoidal; rectangular; triangular; rounded; micro-butt; aviform; partitioned
8	chapeau de gendarme	yes / no
9	butt-length	in mm
10	butt-thickness	in mm
11	flaking angle	in degrees
12	point of percussion	below ridge; offset to ridge; between ridges; no ridge; indeterminable
13	bulb	normal; pronounced; missing; double
14	length	in mm
15	width	in mm
16	thickness	in mm
17	maximum length	in mm
18	maximum width	in mm
19	number and direction of dorsal negatives	count of negatives (> 1cm) in each sector according to Fig.57, Nr.1
20	scar pattern	unidirectional parallel; unidirectional convergent; perpendicular; bidirectional; semi-centripetal; centripetal; indeterminable
21	edge shape	left and right: straight; convex; concave; convex-concave; irregular
22	edge inclination	converging; parallel; diverging; round / oval
23	edge perfomance	left and right: assessment of usable portion (0%, 10%,...,100%)
24	edge angle	in degrees; measured in sectors according to Fig.57, Nr.2
25	edge cross section	examination of sectors according to Fig.57, Nr.2: straight-straight; concave-straight; convex-straight; straight-concave; straight-convex; concave-convex; convex-concave; biconvex; biconcave; indeterminable
26	longitudinal axis	symmetric; asymmetric; indeterminable
27	deviation between flaking axis and morphological axis	in degrees
28	dorsal symmetry	straight; deviation to the left; deviation to the right; indeterminable
29	longitudinal section	straight; curved; *Concorde*-shaped; twisted to the left; twisted to the right
30	cross section	triangular (equal-sided); scalene; trapezoidal; lenticular; domed
31	flaking accident	hinge fracture; step fracture; *Siret* fracture; splintering; clivage; plunged
32	technological definition	Levallois point; Levallois fake; Levallois blade; *débordant* Levallois flake/blade; non-Levallois blade; non-Levallois flake; Kombewa flake cortical flake; first flake; core tablet; core edge flake; flaking surface preparation flake; striking platform preparation flake; core trimming *sensu lato*; indeterminable
33	Levallois stage	first order; second order; third order; unclear
34	modification	yes / no
35	location of modification	dorsal and ventral face: examination of sectors according to Fig.57, Nr.2
36	depth of retouch	in mm
37	type of modification	edge retouch (substantial); partial retouch; abrupt retouch (backed); planar retouch; denticulation; notch; burin spall removal; thinning
38	intensity of retouch	single; twofold; threefold
39	geometric index of unifacial retouch	according to Kuhn (1990)
40	recycled tool	yes / no
41	typological group	partially retouched piece; simple side scraper; double side scraper; Mousterian point; Upper Paleolithic tool type; notched piece; denticulate; multiple tool; miscellaneous
42	typological definition	according to Borde's typological list

Tab.11: Techno-typological attributes recorded for complete flakes.

Tab.11

	attributes	features
1	object category	core; core fragment; unworked pebble; tested pebble; chopper; chopping tool; indeterminable
2	morphology	discus; tablet; polyhedral; tetrahedral / concical; irregular; indeterminable
3	maximum length	in mm
4	maximum width	in mm
5	maximum thickness	in mm
6	weight	in g
7	n° or surfaces	1, 2, 3,...
8	function of surface	determination for each surface: flaking surface; striking platform; both; unclear
9	n° and direction of negatives	determination for each surface according to Fig.57, Nr.1
10	strategy of exploitation	determination for each surface: unidirectional parallel; unidirectional convergent; perpendicular; bidirectional; semi-centripetal; centripetal; alternating; indeterminable
11	n° of striking platforms	1, 2, 3,...
12	preparation of striking platform	determination for each striking platform: faceted; plain; cortex; clivage; indeterminable
13	circumferential striking platform	yes / no
14	exterior platform angle	measurement of angle between flaking surface and striking platform in degrees
15	flaking accident	none; hinge fracture; step fracture; inclusion; splintering; plunging removal
16	reduction stage	early; exhausted core; unclear
17	technological identification	non-Levallois flake core; non-Levallois blade core; Levallois core; core on flake; unworked cobble; tested cobble; chopping tool; chopper; indeterminable
18	modification	yes / no
19	type of modification	retouch; other
20	typological definition	according to Borde's typological list
additional attributes determined for cores on flakes:		
21	exploitation	dorsal; ventral; both
22	location of breaking surface	none; proximal; distal; mesial left; mesial right; multiple; indeterminable
23	surface quality	homogeneous; rippled; stepped; inclusion; clivage
24	location of secondary negatives	determination of each surface according to Fig.57, Nr.1
25	n° of secondary blank removals	determination of each surface according to Fig.57, Nr.1
26	n° of preparation flake removals	determination of each surface according to Fig.57, Nr.1
27	inclination of blank removals in relation to the blank's flaking axis	in degrees
28	exterior platform angle	measured for each exploited section according to Fig.57, Nr.1
29	maximum length of secondary blank removal	in mm
30	maximum width of secondary blank removals	in mm
31	preparation of striking platform	faceted; flake scar; breaking surface; cortex
32	n° of flaking accidents	determination of each surface according to Fig.57, Nr.1
33	type of flaking accident	determination of each surface according to Fig.57, Nr.1: hinge fracture; step fracture; other
34	maximum length of flake blank	in mm
35	maximum width of flake blank	in mm
36	maximum thickness	measured distal, mesial and proximal
37	type of flake blank	flake; broken flake; tool; broken tool
38	technological identification	dorsal core; ventral core; multiple core

Tab.12: Techno-typological attributes recorded for cores.

	attribute	features
1	part of fragment	determination according to Fig.57, Nr.2
2	refitting	yes / no
3	ID of refitted fragments	
4	fragmentation	modern; old
5	*Siret* fracture	yes / no
6	butt-length	in mm
7	butt-thickness	in mm
8	butt preparation	faceted; faceted cortex; dihedral; plain; cortex; cortex & faceting; splintered; indeterminable
9	butt morphology	rhomboid; trapezoidal; rectangular; triangular; rounded; micro-butt; aviform; partitioned
10	modification	yes / no
11	moment of modification	prior to fragmentation; after fragmentation
12	type of modification	edge retouch (substantial); partial retouch; abrupt retouch (backed); planar retouch; denticulation; notch; burin spall removal; thinning
13	reconstruction	as detailed as possible

Tab.13: Techno-typological attributes recorded for fragments.

level	counts[a]	percent blanks	Levallois flakes	Levallois blades	Levallois points	Levallois total	Levallois frag.	non-Levallois blades	non-Levallois flakes	non-Levallois Kombewa[b]	non-Levallois total	IL
5AI	4	25.0		1		**1**						*100*
5AII	134	39.6	14	19	12	**45**	7	2	4	2	**8**	*85*
5AIII	54	14.8	2	2	3	**7**	8		1		**1**	*88*
5AIV	367	39.8	57	32	49	**138**	33	2	1	5	**8**	*95*
5AV	33	24.2	3	1	4	**8**	3					*100*
5AVI	61	47.5	16	9	4	**29**	3					*100*
5a1	655	15.4	41	30	23	**94**	5	3		4	**7**	*83*
5a2	564	15.2	31	23	21	**75**	27	2	1	8	**11**	*87*
5a3	487	18.3	23	27	24	**74**	37	10	2	3	**15**	*83*
5a4	256	14.1	13	12	9	**34**	20	2			**2**	*94*
5b1	94	21.3	9	8		**17**	4	2	1		**3**	*85*
5BI	9	33.3	1	1	1	**3**						*100*
5b2	133	21.1	11	3	9	**23**	10	1	2	2	**5**	*82*
5BII	85	44.7	14	14	6	**34**	1		3	1	**4**	*89*
5b3	639	23.6	53	51	32	**136**	31	7	6	2	**15**	*90*
5BIII	29	3.4					7			1	**1**	
5b4	36	19.4	2	3	2	**7**	4					*100*
5b5	321	19.9	28	21	7	**56**	32		2	6	**8**	*88*
5b6	27	18.5	1	2	1	**4**	1		1		**1**	*80*
5b7	102	22.5	8	7	6	**21**	9		1	1	**2**	*91*
5c	4	25.0	1			**1**						*100*
5d	12	16.7	1		1	**2**	3					*100*
5DII	2	50.0			1	**1**						*100*
5DIII	4											
5DIV	2											
5DV	46	21.7	1	5	3	**9**	7			1	**1**	*90*
5E	199	27.1	16	22	12	**50**	24			4	**4**	*93*
5e	54	18.5	4	3	2	**9**	10			1	**1**	*90*
5f1	43	34.9	6	5	1	**12**	7	1		2	**3**	*80*
5f2/3	38	50.0	7	9	1	**17**	6	1		1	**2**	*89*
5g	47	23.4	5	5	1	**11**	8					*100*
total	4541		368	315	235	**918**	307	58		44	**102**	

Artifacts retrieved from sedimentological units

unit	counts[a]	percent blanks	Levallois flakes	Levallois blades	Levallois points	Levallois total	Levallois frag.	non-Levallois blades	non-Levallois flakes	non-Levallois Kombewa[b]	non-Levallois total
5a (profiles)	165	55.2	16	16	11	**43**	18	1	2	2	**5**
5b (profiles)	57	93.0	10	10	5	**25**	3	2	1		**3**
5b1+2 (trench W1)	41	58.5	5	2	5	**12**	1				
5b5 (trench W1)	85	29.4	6	4	2	**12**	6		1		**1**
5b5 (trench W3)	34	23.5	2	1	1	**4**	2				
5FI (trench S1)	6	66.7	1		1	**2**					
5d-f (trench W1)	97	43.3	4	6		**10**	7	10	5		**15**
5b3-7(trench W3)	75	93.3	9	12	9	**30**	9		1		**1**
5f	12	16.7	2			**2**	1				
total	572		55	51	34	**140**	47	23		2	**25**

[a] excluding debris <2cm
[b] including Janus flakes

Tab.14: Frequency of Levallois and non-Levallois blanks in single archaeological levels as well as test trench assemblages.

Tab.14

level	counts[a]	percent cores	Levallois cores		flake cores		cores on flakes		indet.	frag.	total
			N	%	N	%	N	%			
5AI	4	25.0			1						**1**
5AII	134	2.2	1	33.3			2	66.7			**3**
5AIII	54	7.4			2	50.0	1	25.0	1		**4**
5AIV	367	3.8	2	14.3	3	21.4	9	64.3			**14**
5AV	33	18.2	2	33.3	2	33.3	2	33.3			**6**
5AVI	61	9.8			3	50.0	3	50.0			**6**
5a1	655	5.6	5	13.5	12	32.4	16	43.2		4	**37**
5a2	564	3.2	3	16.7	4	22.2	10	55.6		1	**18**
5a3	487	4.3	4	19.0	2	9.5	14	66.7		1	**21**
5a4	256	3.5	1	11.1	5	55.6	3	33.3			**9**
5b1	94	5.3			1	20.0	4	80.0			**5**
5BI	9	0.0									**0**
5b2	133	3.8			1	20.0	4	80.0			**5**
5BII	85	4.7	2	50.0			2	50.0			**4**
5b3	639	4.4	4	14.3	16	57.1	8	28.6			**28**
5BIII	29	27.6			1	12.5	6	75.0		1	**8**
5b4	36	0.0									**0**
5b5	321	6.9	2	9.1	6	27.3	11	50.0	2	1	**22**
5b6	27	3.7								1	**1**
5b7	102	3.9	1	25.0	1	25.0	2	50.0			**4**
5c	4	0.0									**0**
5d	12	0.0									**0**
5DII	2	0.0									**0**
5DIII	4	0.0									**0**
5DIV	2	50.0							1		**1**
5DV	46	8.7					4	100.0			**4**
5E	199	5.5	1	9.1	1	9.1	9	81.8			**11**
5e	54	7.4	2	50.0			2	50.0			**4**
5f	12	8.3							1		**1**
5f1	43	2.3					1	100.0			**1**
5f2/3	38	7.9					3	100.0			**3**
5g	47	0.0									**0**
total			**30**	**16.1**	**61**	**32.8**	**116**	**62.4**	**5**	**9**	**221**

Artifacts retrieved from sedimentological units

level	counts[a]	percent cores	Levallois cores		flake cores		cores on flakes		indet.	frag.	total
			N	%	**N**	**%**	**N**	**%**			
5a (profiles)	165	6.7	2	18.2	4	36.4	5	45.5		2	**11**
5b (profiles)	57	5.3					3	100.0			**3**
5b1+2 (trench W1)	41	9.8			2	50	2	50.0			**4**
5b5 (trench W1)	85	10.6	2	22.2	5	55.6	2	22.2			**9**
5b5 (trench W3)	34	2.9					1	100.0			**1**
5FI (trench S1)	6	16.7					1	100.0			**1**
5d-f (trench W1)	97	4.1									**4**
5b3-7(trench W3)	75	9.3			3	42.9	3	42.9			**7**

[a] excluding debris <2cm

Tab.15: Frequency of Levallois cores, cores on flakes, simple flake cores, indeterminable core types and core fragments in single archaeological levels as well as test trench assemblages.

Tab.15

Tab.16

	N	% of all cores	length mean	width mean	thickness mean	weight (g) mean	LWR mean	EPA mean
Levallois point cores								
lineal type	3	1.4	6.1	5.9	2.1	67.5	1.0	72
recurrent type	8	3.6	5.7	5.9	1.9	78.4	1.0	64
on flake	3	1.4	5.6	5.2	1.6	36.0	1.1	78
Levallois flake / blade cores								
lineal type	3	1.4	5.8	5.9	2.3	74.7	1.0	61
recurrent type	11	5.0	5.9	5.0	2.2	64.8	1.2	72
total analyzed	28	12.7						

Tab.16: Frequency and basic metrics of Levallois cores. The length width ratio (LWR) is the ratio between the cores' maximum length and width. The exterior platform angle (EPA) is the intersection angle between the flaking surface and striking platform.

	blades		flakes		points		total	
	N	%	N	%	N	%	N	%
triangular	100	*33.1*	103	*29.7*	204	*91.5*	407	*46.7*
quadrangular	49	*16.2*	66	*19.0*	2	*0.9*	117	*13.4*
rounded / oval	15	*5.0*	24	*6.9*	2	*0.9*	41	*4.7*
polygonal	131	*43.4*	149	*42.9*	14	*6.3*	294	*33.7*
conical / tetraedic	1	*0.3*	2	*0.6*	0	*0.0*	3	*0.3*
irregular	6	*2.0*	3	*0.9*	1	*0.4*	10	*1.1*
total analyzed	302	*100.0*	347	*100.0*	223	*100.0*	872	*100.0*

Tab.17: Classification of Levallois blank categories (all levels grouped) according to shape.

Tab.17

	N	% of Levallois blanks	length	width	thickness	LWR	RT	atypical points
			mean	mean	mean	mean	mean	N
5AII	12	*27*	7.6	3.4	0.7	2.3	0.12	12
5AIII	3	*43*	7.4	4.1	0.6	1.8	0.11	
5AIV	49	*36*	7.2	3.9	0.6	1.9	0.11	27
5AV	4	*50*	6.9	3.8	0.6	1.9	0.11	1
5AVI	4	*14*	6.0	3.1	0.4	2.0	0.09	15
5a1	23	*24*	5.9	3.1	0.5	2.2	0.13	
5a2	21	*28*	6.4	3.6	0.6	1.7	0.12	8
5a3	24	*32*	7.0	3.8	0.6	1.9	0.12	7
5a4	9	*26*	7.1	3.2	0.6	2.3	0.12	6
5b1							0.12	9
5BI	1	*33*	*7.9*	*5.3*	*0.8*	*1.5*		
5b2	9	*39*	7.3	4.1	0.7	1.7	0.13	4
5BII	6	*18*	7.2	3.9	0.5	2.0	0.10	8
5b3	32	*24*	6.3	3.4	0.5	1.9	0.10	38
5b4	2	*29*	8.1	3.5	0.5	2.4	0.08	
5b5	7	*13*	5.6	2.7	0.4	2.1	0.10	15
5b6	1	*25*	*7.2*	*3.7*	*0.4*	*1.9*	0.07	
5b7	6	*29*	7.6	2.8	0.2	2.8	0.02	
5d	1	*50*	*5.8*	*2.6*	*0.5*	*2.2*	0.12	
5DII	1	*100*	*4.5*	*3.3*	*0.2*	*1.4*	0.05	
5DV	3	*33*	8.3	3.4	0.6	2.4	0.10	
5E	12	*24*	7.2	2.9	0.5	2.6	0.10	5
5e	2	*22*	7.6	3.5	0.9	2.2	0.15	
5f1	1	*8*	*9.1*	*4.6*	*0.9*	*2.0*	0.13	1
5f2	1	*6*	*7.7*	*3.7*	*0.8*	*2.1*	0.14	2
5g	1	*9*	*5.8*	*2.8*	*0.5*	*2.1*	0.12	
total	235		7.0	3.6	0.6	2.1		158

Tab.18: Frequency, basic metrics, length width ratio (LWR) and relative thickness (RT) of Levallois points in each Mousterian assemblage. Triangular flakes which can be classified as atypical Levallois points are listed separately (see text for classification criteria).

Tab.18

Tab.19

	analyzed	unidirectional-parallel		unidirectional-convergent		perpendicular		bidirectional		semi-centripetal		centripetal		indeterminable	
	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%
5AI	1			1	100.0										
5AII	32	14	43.8	13	40.6	2	6.3	2	6.3	1	3.1				
5AIII	4	1	25.0	1	25.0					1	25.0			1	25.0
5AIV	79	22	27.8	47	59.5	2	2.5	2	2.5	3	3.8			3	3.8
5AV	4	1	25.0	2	50.0					1	25.0				
5AVI	22	8	36.4	14	63.6										
5a2	45	26	57.8	9	20.0	4	8.9	1	2.2	2	4.4			3	6.7
5a3	46	27	58.7	11	23.9	7	15.2	1	2.2						
5a4	23	14	60.9	3	13.0	4	17.4	1	4.3			1	4.3		
5b1	16	8	50.0	7	43.8									1	6.3
5BI	2	1	50.0							1	50.0				
5b2	14	11	78.6	1	7.1	2	14.3								
5BII	26	13	50.0	11	42.3	1	3.8							1	3.8
5b3	99	52	52.5	26	26.3	13	13.1	4	4.0	3	3.0	1	1.0		
5b5	38	22	57.9	12	31.6	2	5.3	2	5.3						
5b6	3	1	33.3	2	66.7										
5d	1					1	100.0								
5DV	6	2	33.3	3	50.0	1	16.7								
5E	37	23	62.2	8	21.6	3	8.1					2	5.4	1	2.7
5e	7	1	14.3					3	42.9	2	28.6	1	14.3		
5f1	10	4	40.0					3	30.0	3	30.0				
5f2	15	4	26.7					6	40.0	3	20.0	1	6.7	1	6.7
5g	9	2	22.2			3	33.3	3	33.3	1	11.1				

Tab.19: Frequency distribution of scar pattern types in selected Mousterian assemblages (N>8); levels 5b4 and 5b7 are not included due to a lack of results; assemblage 5a1 is excluded because of a possible contamination.

level	number of Levallois blanks	percent Levallois points	percent Levallois points + blanks with convergent scar pattern	difference
5AI	**1**	0	100	*100*
5AII	**45**	27	56	*29*
5AIII	**7**	43	57	*14*
5AIV	**138**	36	70	*35*
5AV	**8**	50	75	*25*
5AVI	**29**	14	62	*48*
5a1	**5**	40	40	*0*
5a2	**75**	28	40	*12*
5a3	**74**	32	47	*15*
5a4	**34**	26	35	*9*
5b1	**17**	0	41	*41*
5b2	**23**	39	39	*0*
5BI	**3**	33	33	*0*
5BII	**34**	18	50	*32*
5b3	**136**	24	43	*19*
5b4	**7**	29	*not analyzed*	
5b5	**56**	13	34	*21*
5b6	**4**	25	75	*50*
5b7	**21**	29	*not analyzed*	
5c	**7**	0	*not analyzed*	
5d	**2**	50	*not analyzed*	
5DII	**1**	100	100	*0*
5DV	**9**	33	67	*33*
5E	**50**	24	40	*16*
5e	**9**	22	22	*0*
5f1	**12**	8	8	*0*
5f2/3	**17**	6	6	*0*
5g	**11**	9	9	*0*

Tab.20: Index of Levallois point production: percentage of points in Levallois blank samples and the percentage of Levallois points together with blanks showing a convergent scar pattern. The difference between both ratios shows the degree of the quantitative underestimation of Levallois point production which is based on the frequency of Levallois points alone.

Tab.20

Tab.21

	0%		10%		20%		30%		40%		50%		60%		70%		80%	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
5AI			1	100.0														
5AII	39	86.7	5	11.1					1	2.2								
5AIII	5	71.4			2	28.6												
5AIV	108	78.3	21	15.2	4	2.9	3	2.2									2	1.4
5AV	6	75.0	2	25.0														
5AVI	21	72.4	5	17.2	2	6.9			1	3.4								
5a1	4	80.0	1	20.0														
5a2	61	81.3	8	10.7	2	2.6	3	4.0									1	1.3
5a3	57	77.0	10	13.5	4	5.4					1	1.4	1	1.4			1	1.4
5a4	27	79.4	4	11.8	2	5.9	1	2.9										
5b1	14	82.4	1	5.9			2	11.8										
5BI	3	100.0																
5b2	20	87.0	2	8.7					1	4.3								
5BII	28	82.4	3	8.8	1	2.9	1	2.9							1	2.9		
5b3	109	80.1	18	13.2	3	2.2	3	2.2	2	1.5	1	0.7						
5b4	6	85.7			1	14.3												
5b5	44	78.6	9	16.1	2	3.6			1	1.8								
5b6	3	75.0	1	25.0														
5b7	18	85.7	3	14.3														
5d	2	100.0																
5DII	1	100.0																
5DV	6	66.7	3	33.3														
5e	9	100.0																
5E	36	72.0	13	26.0							1	2.0						
5f1	10	83.3	1	8.3									1	8.3				
5f2/3	8	47.1	6	35.3	2	11.8											1	5.9
5g	7	63.6	4	36.4														
total	**681**	**78.1**	**129**	**14.8**	**28**	**3.2**	**16**	**1.8**	**6**	**0.7**	**3**	**0.3**	**2**	**0.2**	**1**	**0.1**	**6**	**0.7**

Tab.21: Frequency and proportion of cortex remains on Levallois blanks.

	analyzed	length		width		thickness		LWR		RT	
	N	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
5AI	1	7.8	-	*3.0*	-	*0.6*	-	*2.6*	-	*0.11*	-
5AII	33	7.1	2.0	3.4	0.8	0.6	0.3	2.2	0.73	0.12	0.04
5AIII	4	7.2	-	3.8	-	0.8	-	2.0	-	0.14	-
5AIV	88	6.8	1.7	3.7	0.9	0.6	0.3	1.9	0.61	0.12	0.04
5AV	4	6.8	-	3.6	-	0.6	-	2.0	-	0.11	-
5AVI	25	6.9	1.9	3.8	0.9	0.6	0.2	1.8	0.37	0.11	0.03
5a1	71	5.9	2.5	3.0	1.2	0.5	0.3	1.9	0.60	0.11	0.04
5a2	54	5.9	2.4	3.4	1.2	0.6	0.3	1.8	0.62	0.13	0.04
5a3	50	7.3	2.4	3.7	1.2	0.7	0.3	2.1	0.60	0.13	0.03
5a4	25	7.4	2.3	3.5	1.2	0.7	0.2	2.2	0.85	0.12	0.03
5b1	17	7.2	-	3.5	-	0.6	-	2.1	-	0.11	-
5BI	2	7.2	-	3.6	-	0.9	-	2.0	-	0.17	-
5b2	14	6.6	-	3.9	-	0.5	-	1.8	-	0.10	-
5BII	28	6.5	1.3	3.2	0.8	0.5	0.2	2.2	0.57	0.11	0.04
5b3	104	7.0	2.3	3.6	1.1	0.6	0.3	2.0	0.60	0.12	0.04
5b4	7	5.8	-	3.2	-	0.5	-	1.8	-	0.12	-
5b5	49	5.2	2.1	2.7	1.1	0.5	0.2	2.1	0.89	0.12	0.04
5b6	3	8.2	-	4.6	-	0.6	-	1.8	-	0.10	-
5b7	15	6.0	-	2.8	-	0.3	-	2.2	-	0.06	-
5d	1	*6.4*	-	*3.2*	-	*0.2*	-	*2.0*	-	*0.04*	-
5DV	6	7.6	-	3.1	-	0.6	-	2.5	-	0.11	-
5E	38	6.7	1.9	3.1	0.8	0.5	0.2	2.3	0.64	0.10	0.04
5e	7	8.8	-	4.8	-	0.7	-	1.9	-	0.12	-
5f1	11	7.2	-	3.8	-	0.8	-	2.0	-	0.15	-
5f2	16	8.8	-	4.0	-	0.9	-	2.2	-	0.14	-
5g	10	7.2	-	4.0	-	0.7	-	1.8	-	0.12	-

Tab.22: Mean length, width, thickness, length width ratio (LWR) and relative thickness (RT) of Levallois flakes and blades in selected Mousterian assemblages. Standard deviations (sd) are only given for levels with N>20.

Tab.22

	N	mean n° of prox. negatives	IF	***chapeau d. gendarme***		**butt**	
				N	%	mean length	mean thickness
5AII	12	5	100.0	8	*66.7*	3.8	0.7
5AIII	3	4	66.7	3	*100*	4.8	0.7
5AIV	49	4	75.5	32	*65.3*	3.9	0.7
5AV	4	4	100.0	3	*75*	4.1	0.9
5AVI	4	3	75.0	1	*25*	3.5	0.5
5a1	23	3	100.0	not analyzed		2.6	0.6
5a2	21	3	95.2	9	*42.9*	3.3	0.6
5a3	24	3	100.0	10	*41.7*	3.3	0.5
5a4	9	3	88.9	5	*55.6*	3.4	0.6
5BI	1	*6*	100.0	1	*100*	*4.7*	*0.8*
5b2	9	3	88.9	4	*44.4*	3.9	0.6
5BII	6	4	83.3	2	*33.3*	4.1	0.6
5b3	32	4	96.9	13	*40.6*	3	0.6
5b4	2	not analyzed	100.0	1	*50*	not analyzed	
5b5	7	3	85.7	3	*42.9*	2.9	0.6
5b6	1	*3*	100.0	1	*100*	*3.6*	*0.3*
5b7	6	not analyzed	100.0	not analyzed		not analyzed	
5d	1	*3*	100.0	0	*0*	*1.7*	*0.5*
5DII	1	*3*	100.0	1	*100*	*2.7*	*0.3*
5DV	3	4	100.0	0	*0*	2.1	0.7
5E	12	4	75.0	3	*25*	2.9	0.6
5e	2	3	50.0	0	*0*	3.8	0.7
5f1	1	*3*	100.0	0	*0*	*1.4*	0.6
5f2	1	*5*	100.0	0	*0*	*4.1*	0.9
5g	1	*4*	100.0	0	*0*	*2.8*	0.5

Tab.23: Technological features in the proximal part of Levallois points: the mean number of proximal negatives, the faceting index (IF), the frequency of chapeau de gendarme shaped butts, and the mean butt size.

Tab.23

assemblages	analyzed	length		width		flaking angle	chapeau de gendarme		IF
		mean	sd	mean	sd	mean	N	%	
5AI	1	*1.3*	-	*0.3*	-	*106*	0	*0.0*	100.0
5AII	33	3.2	1.2	0.6	0.2	107	17	*51.5*	96.9
5AIII	4	2.3	-	0.4	-	111	0	*0.0*	100.0
5AIV	88	3.0	1.2	0.6	0.2	107	40	*45.5*	92.4
5AV	4	3.5	-	0.8	-	110	1	*25.0*	100.0
5AVI	25	3.4	1.1	0.7	0.3	110	5	*20.0*	95.2
5a1	71	2.5	1.2	0.5	0.3	not analyzed	0	*0.0*	86.6
5a2	54	2.4	1.1	0.7	1.1	104	13	*24.1*	94.3
5a3	50	2.6	1.1	0.6	0.2	104	6	*12.0*	91.8
5a4	25	2.9	1.2	0.6	0.3	104	5	*20.0*	87.5
5b1	17	2.9	-	0.6	-	104	4	*23.5*	100.0
5b2	14	2.9	-	0.7	-	104	1	*7.1*	100.0
5BII	28	2.5	0.9	0.6	0.2	107	6	*21.4*	88.5
5b3	104	2.5	1.0	0.6	0.3	106	12	*11.5*	94.9
5b4	7	not analyzed		not analyzed		not analyzed	0	*0.0*	83.3
5b5	49	2.2	1.0	0.7	0.9	106	7	*14.3*	88.9
5b6	3	2.9	-	0.9	-	115	0	*0.0*	66.7
5b7	15	not analyzed		not analyzed		not analyzed	1	*6.7*	92.9
5d	1	*2.3*	-	*0.5*	-	*98*	0	*0.0*	100.0
5DV	6	2.6	-	0.5	-	111	0	*0.0*	100.0
5E	38	2.4	1.1	0.5	0.2	106	7	*18.4*	97.3
5e	7	2.6	-	0.6	-	105	1	*14.3*	100.0
5f1	11	2.3	-	0.6	-	102	0	*0.0*	100.0
5f2	16	3.1	-	0.6	-	107	0	*0.0*	92.3
5g	10	3.1	-	0.7	-	108	3	*30.0*	90.0

Tab.24: Mean butt length, butt width, flaking angle and *chapeau de gendarme* frequency for Levallois flakes and blades in selected Mousterian assemblages. Standard deviations (sd) are only given for assemblages with N>20.

Tab.24

Tab.25

	5AII	5AIV	5a2	5a3	5a4	5b2	5BII	5b3	5b5	5E
N	12	50	21	24	9	9	6	32	7	12
median PBI	1.12	0.99	0.96	0.93	1.06	1.07	1.06	0.91	1.13	1.06
25th percentile	0.93	0.87	0.72	0.80	1.00	0.88	0.87	0.84	0.89	0.76
75th percentile	1.21	1.17	1.00	1.00	1.35	1.06	1.55	1.00	1.22	1.19

Tab.25: Measures of central tendency for PBI values in major Levallois point-bearing assemblages.

Tab.26

	flakes		blades	
	%	total analyzed	%	total analyzed
Levallois blanks of 2nd or 3rd order	49.6	246	60.3	232
parallel edge gradients	37.3	346	48.2	301
trapezoidal cross section	79.7	345	66.6	302
point of percussion				
between two ridges	42.9		32.9	
below central ridge	35.9	340	55.6	295
adjacent to central ridge	18.5		10.8	
no ridge	2.6		0.7	

Tab.26: Analysis of Levallois flake and blade attributes related to the recurrent Levallois method.

Tab.27

		length			width			thickness			LWR[a]	WTR[b]
	counts	mean	median	sd	mean	median	sd	mean	median	sd	mean	mean
first flakes	5	6.7	6.3	-	4.1	3.2	-	1.4	1.4	-	1.6	2.9
initialization flakes	6	8.2	8.5	-	5.9	5.4	-	1.6	1	-	1.4	3.7
cortical flakes	209	4.9	4.4	2.2	3.4	3.1	1.3	0.8	0.7	0.4	1.4	4.3
core tablets	15	6.7	6.3	-	3.4	2.8	-	1	0.9	-	2.0	3.4
striking platform	158	2.4	2.2	0.9	3.4	3.1	1	0.5	0.4	0.2	0.7	6.8
abrasion	6	2.9	2.6	-	1.5	1.3	-	0.5	0.5	-	1.9	3.0
core edge flakes	186	6	5.6	2.2	3.2	3.1	1	0.8	0.7	0.4	1.9	4.0
flaking surface	470	4.7	4.4	1.9	2.9	2.7	1.1	0.5	0.4	0.3	1.6	5.8
core trimming s.l.	462	3.7	3.3	1.5	2.5	2.2	1	0.5	0.4	0.4	1.5	5.0

[a] length:width ratio

[b] width:thickness ratio

Tab.27: Frequency, basic metrics, length width ratio (LWR) and width thickness ratio (WTR) of core trimming elements. Standard deviations are given for samples with N>100 only.

Tab.28

		faceted		faceted cortex		faceted with cortex		total faceted		dihedral		cortical		plain		splintered		indet.	
	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%		
first flakes	5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	60.0	0	0.0	1	20.0	1	20.0
initialisation flakes	6	2	33.3	0	0.0	0	0.0	2	33.3	0	0.0	0	0.0	3	50.0	1	16.7	0	0.0
cortical flakes	209	38	18.2	12	5.7	9	4.3	59	28.2	11	5.3	44	21.1	53	25.4	41	19.6	1	0.5
core tablets	15	9	60.0	0	0.0	1	6.7	10	66.7	0	0.0	1	6.7	4	26.7	0	0.0	0	0.0
abrasion flakes	6	3	50.0	0	0.0	1	16.7	4	66.7	1	16.7	0	0.0	1	16.7	0	0.0	0	0.0
striking platform flakes	158	13	8.2	0	0.0	0	0.0	13	8.2	45	28.5	1	0.6	81	51.3	17	10.8	1	0.6
flaking surface flakes	470	260	55.3	19	4.0	10	2.1	289	61.5	37	7.9	13	2.8	81	17.2	48	10.2	2	0.4
core edge flakes	186	81	43.5	14	7.5	10	5.4	105	56.5	8	4.3	10	5.4	40	21.5	22	11.8	1	0.5
core trimming s.l.	462	105	22.7	11	2.4	12	2.6	128	27.7	41	8.9	24	5.2	176	38.1	87	18.8	6	1.3

Tab.28: Frequency of butt types for each CTE category.

Tab.29

	total analyzed	below ridge		between ridge		off-ridge		no ridge		indeterminable	
		N	%	N	%	N	%	N	%	N	%
Levallois blades	302	164	54.3	97	32.1	32	10.6	2	0.7	7	2.3
Levallois flakes	347	122	35.2	147	42.4	63	18.2	9	2.6	6	1.7
Levallois points	223	48	21.5	157	70.4	8	3.6	2	0.9	8	3.6
faceted flak. surf. flakes	290	131	45.2	43	14.8	60	20.7	54	18.6	2	0.7
unfaceted flak. surf. flakes	133	61	45.9	16	12.0	22	16.5	31	23.3	3	2.3

Tab.29: Blow orientation patterns among Levallois blank types and flaking surface flakes (see text for a description of orientation patterns).

levels	raw material type		
	EF	CF	LI
5AII	110	1	
5AIII	17		
5AIV	270	3	
5AV	25		
5AVI	49	1	1
5a1	22		
5a2	359		2
5a3	312	4	5
5a4	136	3	1
5b1	59		2
5b2	85		
5BII	78		
5b3	472	6	2
5b5	166	2	2
5b6	15		
5DV	29	1	
5E	122	1	
5e	37	1	
5f1	31		
5f2	26		
5g	25		

Tab.30: Raw material composition of selected Mousterian assemblages with N>10 analyzed items. EF = Eocene flint; CF = Cretacious flint; LI = limestone.

Tab.30

blank type	dorsal cores		ventral cores		multiple cores		total	
	N	%	N	%	N	%	N	%
flake	24	*34.8*	17	*56.7*	2	*22.2*	44	*40.4*
broken flake	33	*47.8*	13	*43.3*	5	*55.6*	51	*46.8*
tool	2	*2.9*					2	*1.8*
broken tool	10	*14.5*			2	*22.2*	12	*11.0*
total analyzed	69	*100.0*	30	*100.0*	9	*100.0*	109	*100.0*

Tab.31: Selection of blank types according to core on flake types.

blank types	**N**	***%***
flakes sensu largo	62	*56.9*
CTEs	20	*18.3*
Levallois blanks	13	*11.9*
side scrapers	13	*11.9*
Kombewa flakes	1	*0.9*
total analyzed	109	*100.0*

Tab.32: Frequency of technological blank types found in the core on flake sample.

Tab.32

Tab.33

	analyzed	length				width				thickness			
		mean	min	max	sd	mean	min	max	sd	mean	min	max	sd
dorsal cores	68	57.4	28	105	16.5	44.7	22	73	10.5	11.4	5	23	4.2
ventral cores	29	60.3	27	93	17.5	43.9	25	69	9.3	15.7	7	27	5.4
multiple cores	9	49.6	40	61	5.7	35.6	24	43	5.8	12.3	9	17	3.0

Tab.33: Metric attributes of different core on flake categories (measured in mm).

exploited sections	dorsal cores		ventral cores		multiple cores	
	N	%	N	%	N	%
distal	8	*11.6*	11	*36.7*		
proximal	51	*73.9*	9	*30.0*	3	*33.3*
mesial	1	*1.4*	4	*13.3*		
distal + mesial			1	*3.3*	1	*11.1*
distal + proximal	3	*4.3*	3	*10.0*	2	*22.2*
mesial + proximal	3	*4.3*	1	*3.3*	1	*11.1*
mesial left + right	1	*1.4*	1	*3.3*		
distal + mesial + proximal	2	*2.9*				
mesial + mesial + proximal					2	*22.2*

Tab.34: Reduction intensity of cores on flakes determined by the number of exploited sections.

	analyzed	length (mm)		width (mm)		LWR		
		mean	sd	mean	sd	mean	median	sd
dorsal cores	69	24	9	17	7	1.4	1.3	0.6
ventral cores	30	27	11	20	8	1.4	1.1	1.0
multiple cores	9	17	5	14	2	1.3	1.4	0.5

Tab.35: Mean length, width and length-width-ratio (LWR) of secondary flake removals on different core on flake types.

cores on flakes exploited in one sector

type	analyzed	faceted		plain		breakage		cortex	
		N	%	N	%	N	%	N	%
dorsal cores	59	48	*81.4*	3	*5.1*	8	*13.6*		
ventral cores	24	16	*66.7*	2	*8.3*	3	*12.5*	3	*12.5*
multiple cores	3	1	*33.3*	2	*66.7*				

cores on flakes exploited in two or more sectors

type	analyzed	faceted		faceted & unfaceted		unfaceted	
		N	%	N	%	N	%
dorsal cores	9	4	*44.4*	5	*55.6*		
ventral cores	6	1	*16.7*	5	*83.3*		
multiple cores	6	2	*33.3*	3	*50.0*	1	*16.7*

Tab.36: Frequency of prepared vs. unprepared (breakages, plain and cortical) striking platforms in each core on flake category. Cores on flakes which were reduced from a single platform are listed in the upper table, and cores on flakes with more than one striking platform are shown in the lower table.

	mean	sd	Min	Max
length	4.3	1.9	1.5	9.3
width	3.0	0.9	1.5	5.4
thickness	0.5	0.2	0.2	0.8
LWR	1.6	0.9	0.4	5.2
RT	0.2	0.1	0.0	0.3

Tab.37: Size, length width ratio (LWR) and relative thickness (RT) of Kombewa and Janus flakes.

levels	flakes	fragments	cores	travertine debris	% of complete assemblage
5AIV		1			*0.3*
5a2	2	2			*0.7*
5a3	4	2			*1.2*
5a4	1	2			*1.2*
5b1	1	1	1	2	*5.3*
5b2		2			*1.5*
5b3	3				*0.5*
5b5	2	1	1	3	*2.2*
5b7		1			*1.0*
5c		1			*2.9*
sedimentological units					
5b (profiles & trench W3)	1	1			*3.5*
5b1+2 (trench W1)		1			*2.4*
5b5 (trench W1)		1			*0.8*
5d-f (trench W1)		1			*1.0*
total	**14**	**16**	**2**	**5**	***1.1***

Tab.38: Frequency of limestone flakes, fragments and cores as well as travertine debris in single levels and test trench assemblages from Hummal.

Tab.38

level	retouched tools	tool fragments	recycled tools[a]	total	percent of assemblage	extended percent of assemblage[b]
5AII (134)	13	17		**30**	*9.7*	*46.3*
5AIII (54)	3	3		**6**	*5.6*	*18.5*
5AIV (367)	19	29	2	**50**	*5.2*	*45.5*
5AV (33)	2	2		**4**	*6.1*	*30.3*
5AVI (61)	10	11		**21**	*16.4*	*65.6*
5a1 (646)	9	2	1	**12**	*1.4*	*14.9*
5a2 (565)	28	34	3	**65**	*5.0*	*19.3*
5a3 (487)	27	31	1	**59**	*5.5*	*21.6*
5a4 (256)	14	22	1	**37**	*5.5*	*21.9*
5b1 (94)	10	9		**19**	*10.6*	*27.7*
5BI (9)	2	2		**4**	*22.2*	*55.6*
5b2 (133)	10	11	1	**22**	*7.5*	*25.6*
5BII (85)	6	7	1	**14**	*7.1*	*48.2*
5b3 (639)	44	48		**92**	*6.9*	*28.8*
5b4 (39)	1	1		**2**	*2.6*	*20.5*
5b5 (321)	7	11	2	**20**	*2.2*	*20.9*
5b6 (27)	2	2		**4**	*7.4*	*22.2*
5b7 (102)	4	4		**8**	*3.9*	*24.5*
5DV (46)	2	2		**4**	*4.3*	*23.9*
5E (199)	12	13	1	**26**	*6.0*	*31.7*
5e (54)	4	4		**8**	*7.4*	*24.1*
5f1 (43)	6	7		**13**	*14.0*	*44.2*
5f2 (38)	9	9	1	**19**	*23.7*	*68.4*
5g (47)	3	4		**7**	*6.4*	*31.9*
sedimentological units:						
5a (profiles)	18	19	3	**40**	*10.9*	*37.6*
5b (profiles)	6	7		**13**	*10.5*	*56.1*
5b1+2 (trench W1)	2	3	1	**6**	*4.9*	*36.6*
5b5 (trench W1)	2			**2**	*2.4*	*14.1*
5d-f (trench W1)	12			**12**	*12.4*	*10.3*

[a] reused tools for secondary flake production
[b] including non-retouched Levallois blanks (Borde's types 1-3), Pseudo-Levallois points (type 5), and naturally backed knives (type 38)

Tab.39: Frequency of retouched artifacts in single Mousterian levels and test trench units of Hummal.

Tab.40

Bordes-Nr	type	N	% real	% restr.[b]	5AI	5AII	5AIII	5AIV	5AV	5AVI	5a1	5a2	5a3	5a4	5b1	5b2	5b3	5b4	5b5	5b6	5b7	5BI	5BII	5BIII	5d	5DII	5DV	5E	5e	5f1	5f2	5g
1	Levallois flake	671	41.5	-		33	4	85	4	25	71	54	49	25	17	14	102	5	49	3	15	2	26		1		6	38	7	11	16	9
2	atypical Levallois flake	295	18.2	-	1	26	1	22	1	3	17	27	34	16	5	10	47	6	16	2	3	1	9		1		2	8	4	4	1	4
3	Levallois point	234	14.5	-		12	3	49	4	4	23	21	24	9		9	32	2	7	1	6	1	6			1	3	12	2	1	1	1
4	retouched Levallois point	19	1.2	5.4				3			1		3	1		1	3					1	1					2				
5	pseudo-Levallois point	16	1.0	4.5				2				5	1	5			1		2													
6	Mousterian point	17	1.1	4.8							3	4	3			3	1															
7	elongated Mousterian point	2	0.1	0.6				1																				1				
8	*limace*	0	0.0	0.0																												
9	single straight side scraper	17	1.1	4.8			1	3				5	1		1		2						2					2				
10	single convex side scraper	27	1.7	7.6		2		1	1	4	1	4	3		2	1														2	1	1
11	single concave side scraper	8	0.5	2.3								1	1	3														1		1		
12	double straight side scraper	4	0.2	1.1			1						1															1		1		
13	double straight-convex side scraper	9	0.6	2.5						1			3							1			1				1					1
14	double straight-concave side scraper	2	0.1	0.6		1								1																		
15	double convex side scraper	10	0.6	2.8					1				1	1			3				1								1		1	
16	double concave side sdcraper	0	0.0	0.0																												
17	double concave-convex side scraper	3	0.2	0.8		1						1																			1	
18	convergent straight scraper	7	0.4	2.0				1		1		1					2					1						1				
19	convergent convex scraper	16	1.0	4.5				1			1	1		2	3	2																
20	convergent concave scraper	1	0.1	0.3						1																						
21	*déjeté* scraper	1	0.1	0.3																												
22	straight transverse scraper	1	0.1	0.3																			1									
23	convex transverse scraper	0	0.0	0.0																												
24	concave transverse scraper	0	0.0	0.0																												
25	side scrapers on ventral face	4	0.2	1.1				1									1		1													
26	abrupt retouched side scraper	0	0.0	0.0																												
27	side scraper with thinned back	0	0.0	0.0																												
28	side scraper with bifacial retouch	0	0.0	0.0																												
29	alternate retouched side scraper	3	0.2	0.8							1																	1		1		
30	typical end scraper	1	0.1	0.3				1																								
31	atypical end scraper	2	0.1	0.6				2																								
32	typical burin	3	0.2	0.8												1					1											
33	atypical burin	5	0.3	1.4											2	1		1														
34	typical borer	1	0.1	0.3																												
35	atypical borer	0	0.0	0.0																												
36	typical backed knife	0	0.0	0.0																												
37	atypical backed knife	0	0.0	0.0																												
38	naturally backed knife	40	2.5	11.3		4		8		1	1	2	5	3		1	4		2				1					1		1		1
39	*raclette*	1	0.1	0.3										1																		
40	truncated blade and flake	8	0.5	2.3								1		1			4										1					
40a	truncated-faceted pieces / Nahr Ibrahim type	81	5.0	22.9		1		6	2	1	1	8	12	2	3	4	7		7				2	5				7	2	1	2	

(continued)

Tab.40

Bordes-Nr	type	total			5AI	5AII	5AIII	5AIV	5AV	5AVI	5a1	5a2	5a3	5a4	5b1	5b2	5b3	5b4	5b5	5b6	5b7	5BI	5BII	5BIII	5d	5DII	5DV	5E	5e	5f1	5f2	5g
41	Mousterian tranchet	**0**	**0.0**	**0.0**																												
42	notches	**23**	**1.4**	**6.5**		2		1				1	1			1	6	2	2	1	1							1		1		1
43	denticulates	**12**	**0.7**	**3.4**		2		1				1		2			4		1													
44	alternate retouched beak	**1**	**0.1**	**0.3**																											1	
45	retouch on ventral face	**14**	**0.9**	**-**		1	1	3				2	1	1			4	1														
46	abrupt and alternate retouch (thick)	**0**	**0.0**	**-**																												
47	abrupt and alternate retouch (thick)	**0**	**0.0**	**-**																												
48	abrupt and alternate retouch (thin)	**0**	**0.0**	**-**																												
49	abrupt and alternate retouch (thin)	**0**	**0.0**	**-**																												
50	bifacial retouch	**0**	**0.0**	**-**																												
51	*Tayac* point	**0**	**0.0**	**0.0**																												
52	notched triangle	**0**	**0.0**	**0.0**																												
53	pseudo-microburin	**0**	**0.0**	**0.0**																												
54	end-notched piece	**0**	**0.0**	**0.0**																												
55	*hachoir*	**0**	**0.0**	**0.0**																												
56	*rabot*	**0**	**0.0**	**0.0**																												
57	tanged point	**0**	**0.0**	**0.0**																												
58	tanged tool	**0**	**0.0**	**0.0**																												
59	chopper	**1**	**0.1**	**0.3**									1																			
60	inverse chopper	**0**	**0.0**	**0.0**																												
61	chopping tool	**3**	**0.2**	**0.8**								1	1		1																	
62	miscellaneous	**4**	**0.2**	**1.1**		1					1	1																				
106[a]	partially retouched Non-Levallois flake	**19**	**1.2**	**5.4**							1	1	4				8		1									1				
	partially retouched Levallois flake	**32**	**2.0**	**9.1**		3				1		2	3	1	1		5		2		1		1					1	3		5	
total		**1618**	**100.0**	**100.0**	**1**	**89**	**11**	**191**	**13**	**42**	**122**	**144**	**152**	**74**	**35**	**48**	**236**	**17**	**90**	**8**	**28**	**6**	**50**	**5**	**2**	**1**	**13**	**78**	**19**	**24**	**29**	**18**

[a] type defined by Goren-Inbar (1990)

[b] percentage of tool types based on restricted counts (excluding types 1-3 and 45-50)

Tab.40: The frequency of individual tool types (according to Borde's type-list) in the Mousterian levels of Hummal.

Tab.41

levels	ILty			IR			Group II			Group III			Group IV			Group IV enlarged		
	N	real	restricted	N	real	restricted	N	real	restricted	N	real	restricted	N	real	restricted	N	real	restricted
5AII	71	82.6	0.0	4	4.7	28.6	4	4.7	28.6	1	1.2	7.1	2	2.3	14.3	4	4.7	28.6
5AIV	159	83.2	1.6	7	3.7	21.9	10	5.2	31.3	9	4.7	28.1	1	0.5	3.1	2	1.0	6.3
5a1	112	92.6	0.8	3	2.5	30.0	6	5.0	60.0	1	0.8	10.0	0	0.0	0.0	0	0.0	0.0
5a2	102	72.3	0.0	13	9.2	35.1	22	15.6	59.5	9	6.4	24.3	1	0.7	2.7	2	1.4	5.4
5a3	110	75.9	2.1	10	6.9	27.0	14	9.7	37.8	12	8.3	32.4	0	0.0	0.0	1	0.7	2.7
5a4	51	69.9	1.4	7	9.6	31.8	12	16.4	54.5	3	4.1	13.6	2	2.7	9.1	2	2.7	9.1
5b3	184	82.5	1.3	8	3.6	21.1	10	4.5	26.3	11	4.9	28.9	4	1.8	10.5	10	4.5	26.3
5b5	72	82.8	0.0	1	1.1	6.7	3	3.4	20.0	7	8.0	46.7	1	1.1	6.7	3	3.4	20.0
5E	60	78.9	2.6	6	7.9	33.3	7	9.2	38.9	7	9.2	38.9	0	0.0	0.0	1	1.3	5.6

Tab.41: Typological indices for selected Mousterian assemblages with N>100 complete flakes.

Tab.42

tool categories	analyzed	length				width				thickness				LWR	
		mean	sd	min	max	mean	sd	min	max	mean	sd	min	max	mean	sd
single side scrapers	52	7.7	2.0	2.9	11.8	4.1	1.1	2.2	7.0	0.7	0.3	0.3	1.3	2.0	0.5
double side scrapers / Mousterian points	67	9.0	2.0	3.0	15.1	4.4	0.9	2.0	6.3	0.9	0.3	0.3	1.6	2.1	0.6
partially retouched flakes	69	7.4	2.2	3.0	13.0	3.9	1.0	1.0	6.0	0.8	0.3	0.2	2.1	2.0	0.6
ventrally retouched flakes	14	7.1	1.3	5.0	8.9	3.3	1.1	1.9	5.2	0.9	0.4	0.5	2.2	2.3	0.6
Upper Paleolithic tool types[a]	14	6.7	2.0	3.2	10.1	3.1	1.1	1.4	5.5	0.8	0.3	0.4	1.5	2.4	1.0
denticulates	10	6.9	2.1	3.4	9.3	3.8	0.7	2.5	4.7	0.7	0.2	0.4	1.0	1.9	0.6
notches	17	7.0	2.7	3.2	13.3	3.8	1.1	1.7	5.7	0.9	0.5	0.3	2.1	1.9	0.6

[a] cores on flakes (type 40a) excluded

Tab.42: Mean size and length width ratio (LWR) of major tool types.

tool category	retouch depth (mm)		retouch location		mean edge angle
	median	sd	right	left	
partially retouched blanks	4	2.4	65%	35%	41°
single side scrapers	6	2.8	63%	37%	41°
double / convergent scrapers / Mousterian points	8	3.8	both		43°
UP tools[a]	6	17.2	100%	0%	-
notched pieces	4	1.3	50%	50%	47°
denticulates	3	2.5	75%	25%	45°

[a] type 40 ("truncated-faceted pieces" / cores on flakes) excluded

Tab.43: Mean depth of retouch, mean retouched edge angle, and the location of retouch according to flake edge among major tool groups.

industry	levels
HM-A1	5a1, 5AI, 5AII, 5AIII, 5AIV, 5AV, 5AVI
HM-A2	5a2, 5a3, 5a4, 5b1, 5BI, 5b2, 5BII, 5b3, 5BIII, 5b4, 5b5, 5b6, 5b7, 5c, 5d, 5DV, 5E
HM-B	5e, 5f1, 5f2, 5g

Tab.44: Attribution of single levels to the Mousterian Industries of Hummal.

Tab.44

Tab.45

size difference of Levallois blanks between HM-A1 and HM-A2			length mean	width mean	thickness mean	LWR mean	RT mean
Levallois points		**HM-A1**	7.2	3.8	0.6	2.0	0.11
		HM-A2	6.8	3.5	0.6	2.0	0.11
	comparison between HM-A1 and HM-A2	*T value*	*1.275*	*1.637*	*0.843*	*0.299*	*0.497*
		p value	*0.204*	*0.103*	*0.400*	*0.765*	*0.620*
		HM-B	7.5	3.6	0.8	2.1	0.14
Levallois flakes		**HM-A1**	6.3	4.0	0.7	1.6	0.12
		HM-A2	5.9	3.8	0.6	1.6	0.13
	comparison between HM-A1 and HM-A2	*T value*	*1.571*	*1.285*	*2.068*	*-0.568*	*-1.197*
		p value	*0.117*	*0.200*	*0.039*	*0.571*	*0.232*
		HM-B	7.0	4.5	0.7	1.6	0.13
Levallois blades		**HM-A1**	8.1	4.1	0.8	2.6	0.12
		HM-A2	6.7	3.5	0.6	2.5	0.11
	comparison between HM-A1 and HM-A2	*T value*	*4.113*	*4.046*	*5.459*	*0.517*	*0.815*
		p value	*0.000*	*0.000*	*0.000*	*0.605*	*0.416*
		HM-B	9.3	3.8	0.9	2.5	0.14
Levallois flakes & blades (grouped)	*comparison between HM-A and HM-B*	*T value*	*-4.158*	*-4.051*	*-4.735*	*0.344*	*-2.518*
		p value	*0.000*	*0.000*	*0.000*	*0.731*	*0.012*
coefficient of variation (CV) of all Levallois blanks		**HM-A1**	*0.25*	*0.25*	*0.41*		
		HM-A2	*0.33*	*0.32*	*0.44*		
		HM-B	*0.33*	*0.28*	*0.32*		

variance within groups is equal in each case

Tab.45: Difference between the Hummalian Mousterian Industries HM-A1, HM-A2 and HM-B in respect to the mean size, length width ratio (LWR), and relative thickness (RT) of Levallois blank types.

cortex type	N	%	derived origin of raw material
fresh	437	40.5	primary outcrop
weathered	121	11.2	secondary outcrop
neocortex	61	5.6	secondary outcrop
inner	298	27.6	unknown
indeterminable	163	15.1	unknown
total	1080	100.0	

Tab.46: Frequency of cortex types determined on cortex-bearing flakes of Hummal Mousterian (grouped assemblages) and the hypothetical area of raw material procurement.

assemblage	N	% of all cores	% in total assemblage	d/nc ratio[a]
5AII	1	33	0.9	44
5AIII	2	67	11.8	12.5
5AIV	5	36	1.8	25.4
5AV	4	67	16.0	4.8
5AVI	3	50	5.9	8
5a2	7	41	1.9	28.7
5a3	6	30	1.9	19.7
5a4	6	67	4.3	27.7
5b1	1	20	1.6	18.8
5b2	1	20	1.2	27
5BII	2	50	2.5	20.3
5b3	20	71	4.1	22.3
5BIII	1	13	3.5	2.9
5b4	0	0	0.0	
5b5	8	42	4.5	13.7
5b7	2	36	2.6	19.4
5DV	0	0	0.0	
5E	2	18	1.5	15.7
5e	2	50	6.9	10.6
5f1	0	0	0.0	
5f2	0	0	0.0	
5g	0	0	0.0	
total	**73**	**mean: 32.3**	**mean: 3.3**	**mean: 19.83**

[a] debitage to nodule core ratio (fragments included; debris < 2cm excluded)

Tab.47: The frequency of nodule cores in and the debitage to nodule core ratio in selected Mousterian assemblages. Levels 5a1 and 5b6 were excluded from analysis because of contamination (5a1) and incomplete excavation (5b6).

assemblage	N	mean	median	25th percentile	75th percentile
5AII	52	7.3	7.6	6.1	8.6
5AIV	145	6.7	6.6	5.4	8.1
5a2	86	5.8	5.7	3.6	7.3
5a3	90	5.8	7.1	4.9	8.7
5b3	152	6.7	6.9	4.9	7.9
5b5	63	5.1	4.6	3.8	6.6
ANOVA					
F:	9.514				
P:	0.000				
t-test for 5b3 and 5b5					
t:	4.638				
p:	0.000				

Tab.48: Mean and median length values of blanks in selected Mousterian levels (N>50) together with the upper and lower quartiles. The analysis of variance (ANOVA) shows that the variability of blank length between levels is significant. Level 5b5 contains the shortest blanks and is significantly different in this respect from overlying level 5b3.

assemblage	**length class (cm)[a]**	**import value**	**recurrent correction**	**blank ratio[b]**	***assemblage type***
5AII	6-7	0.51	0.13	0.41	*1*
5AIII	6-7	0.86	0.29	0.50	*1*
5AIV	5-6	0.49	0.11	0.53	*1*
5AV	6-7	0.43	0.11	0.42	*1*
5AVI	5-6	0.36	0.04	0.64	*2*
5a2	5-6	0.45	0.13	0.22	*3*
5a3	6-7	0.46	0.13	0.24	*3*
5a4	6-7	0.56	0.16	0.26	*3*
5b1	5-6	0.44	0.09	0.30	*3*
5b2	6-7	0.40	0.10	0.28	*3*
5BII	5-6	0.48	0.09	0.45	*2*
5b3	5-6	0.44	0.10	0.29	*3*
5b5	4-5	0.33	0.06	0.35	*2*
5DV	6-7	0.90	0.30	0.36	*1*
5E	6-7	0.42	0.10	0.42	*1*
5e	7-8	0.60	0.17	0.36	*1*
5f1	5-6	0.59	0.17	0.40	*1*
5f2	6-7	0.59	0.16	0.74	*1*
5g	5-6	0.32	0.02	0.44	*2*

[a] length class in which the point of intersection between the frequency distributions for blanks and CTEs is found

[b] ratio of blanks in the flake assemblage (excluding cores, fragments and debris)

Tab.49: Quantification of imported blanks in selected Mousterian assemblages. The second column shows the length class in which L* is located (Fig.109). The import value and corrected import value quantify the amount of imported Levallois blanks (see text for calculation of both values). The ratio of blanks in the flaked assemblages is given as a control variable. Assemblage types in column 6 are theoretically defined on the basis of import values.

Tab.49

assemblage	frequency of pieces with ≥ 3 retouched sections	frequency of pieces with ≥ 3 retouched sections and ≥ 2 retouch events			frequency of pieces with edge angle > 47° and retouch width > 10mm	
	N	N	% of complete debitage	% of all retouched pieces	N	GIUR (mean)
5AII	4	1	0.9	7.7	1	*not analyzed*
5AIII	3	0	0.0	0.0	0	
5AIV	6	4	1.5	21.1	4	0.58
5AV	2	2	10.5	100.0	1	
5AVI	8	3	6.7	30.0	3	0.44
5a2	13	3	0.9	11.1	1	0.72
5a3	14	3	1.0	12.0	2	0.65
5a4	9	1	0.8	7.1	0	
5b1	6	1	1.8	11.1	0	
5BI	1	1	11.1	50.0	0	
5b2	7	2	2.5	20.0	2	1.00
5BII	2	0	0.0	0.0	0	
5b3	10	2	0.4	4.7	0	
5b5	0	0	0.0	0.0	0	
5DV	1	0	0.0	0.0	0	
5E	8	2	1.7	16.7	2	0.67
5e	2	0	0.0	0.0	0	
5f1	4	0	0.0	0.0	0	
5f2	4	0	0.0	0.0	0	
5g	2	1	4	33.3	1	*not analyzed*
total	**106**	**26**			**17**	

Tab.50: Quantification of potentially maintained tools in retouched tool samples of selected Mousterian assemblages.

assemblage	counts	cortex type			
		weathered		fresh	
		N	%	N	%
5AII	31	15	48%	16	52%
5AIV	45	22 (1)	49%	22 (1)	51%
5AVI	12	5 (1)	42%	7 (1)	58%
5a2	69	20	29%	49 (4)	71%
5a3	98	19 (1)	19%	79 (3)	81%
5a4	47	14 (1)	30%	33 (2)	70%
5b1	17	4	24%	13	76%
5b2	24	3 (1)	13%	21	88%
5BII	13	5	38%	8 (2)	62%
5b3	151	38 (3)	25%	113 (6)	75%
5b5	45	12 (2)	27%	33 (2)	73%
5E	18	5	28%	13 (1)	72%

Tab.51: Frequency of cortex-bearing flakes and cores grouped according to the weathering state of the cortical surface (selected assemblages with N>10 analyzable artifacts). The number of cores in each group is given in parenthesis.

level	aspects of case allocation
5AII	presence of maintained tools, high blank ratio and import support an allocation to case 2a; high proportion of primary preparation flakes and moderate nodule core ratio support an allocation to case 1a
5AIII	all values support an allocation to case 2a, except high nodule core ratio
5AIV	all values support an allocation to case 2b
5AV	presence of maintained tools, high blank ratio and absence of primary preparation flakes support an allocation to case 2a; high nodule core ratio and low import value speak support an allocation to case 1a
5AVI	all values support an allocation to case 2a, except high nodule core ratio and low import value
5a2	all values support an allocation to case 1b; moderate import value indicates the presence of imported blanks; low primary preparation flake and nodule core ratios caused by intensive core reduction
5a3	all values support an allocation to case 1b; higher primary preparation flake and nodule core ratios compared to 5a2 are presumably caused by import of lower core volumes
5a4	all values support an allocation to case 1b, except high import value
5b1	all values support an allocation to case 1a, except presence of maintained tools and moderate blank ratio
5b2	all values support an allocation to case 1b, except low nodule core ratio and many maintained tools
5BII	all values support an allocation to case 2a, except moderate nodule core ratio and absence of maintained tools
5b3	all values support an allocation to case 1b
5b5	all values support an allocation to 1b; high nodule core ratio, primary preparation flake ratio and blank ratio presumably caused by the import of small nodules and cores
5DV	all values support an allocation to case 1a, except moderate blank ratio and high import value
5E	high primary preparation flake ratio and low import value support an allocation to case 1b; low nodule core ratio, high blank ratio and presence of maintained tools support an allocation to case 2b; assemble structure roughly comparable to level 5AIV
5e	absence of primary preparation flakes, high blank ratio, high import value support an allocation to case 2a; high nodule core ratio and absence of maintained tools support an allocation to case 1a
5f1	all values support an allocation to case 2a, except high primary preparation flake ratio and absence of maintained tools
5f2	all values support an allocation to case 2a; high primary preparation flake ratio is caused by the presence of only one cortical flake
5g	all values support an allocation to case 2a, except high primary preparation flake ratio and low import value (interdependent); palimpsest

Tab. 52: Allocation of selected Mousterian levels to the theoretical cases defined in Fig.111. Levels 5AI, 5a1, 5BI. 5BIII, 5b4, 5b7, 5c, 5d, 5DI, 5DII, 5DIII, and 5DIV are not comprised because of insufficient data. Level 5a1 is not comprised because of the possibility of contamination.

Tab.52

discriminant vector	% of variance	Wilk's lambda	p
1	53.5	0.009	0.000
2	30.8	0.069	0.000
3	15.7	0.335	0.002

cluster centroids:

cluster	1st vector	2nd vector	3d vector
1	-1.00	2.33	-1.18
2	4.65	0.18	0.29
3	-0.85	-1.98	-0.52
4	-1.62	0.67	2.33

Euclidean distance between cluster centroids:

$d_{2,4}$	6.62
$d_{1,2}$	6.22
$d_{2,3}$	5.96
$d_{1,3}$	4.36
$d_{3,4}$	3.97
$d_{1,4}$	3.94

Tab.53: Results of the discriminant analysis for testing the statistical significance of the clusterings and the distance between the four groupings.

Tab.53

Tab.54

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
levels	5b5, 5DV, 5f1(?)	5AII, 5AIV, 5BII, 5E	5a2, 5a3, 5a4, 5b1, 5b2, 5b3	5AIII, 5AV, 5e
procurement strategy: **- primary outcrops** **- secondary outcrops**	 blanks ~ cores few pebbles	 blanks > cores many pebbles	 nodules, cores > blanks few pebbles	 nodules, cores > blanks ?
transport	direct	direct	direct	delayed
on-site core reduction	intensive	low-scale	intensive	low-scale
need for retouched tools	variable	variable	low	high
occupation span	long	short & long	short & long	short

Tab.54: The four Mousterian assemblage groupings representing different modes of raw material provisioning, variable intensities of on-site core reduction, use of retouched tools, and varying spans of occupation.

	Nadaouiyeh remanié		Nadaouiyeh trench P50	
	N	%	N	%
core trimming elements:				
first flakes	1	0.9	1	0.4
cortical flakes			31	13.2
core tablets			3	1.3
core edge flakes	5	4.7	13	5.5
striking platform flakes	1	0.9	29	12.3
flaking surface flakes	5	4.7	21	8.9
core trimming elements s.l.	4	3.7	18	7.7
fragments > 2cm:			24	10.2
blanks:				
Levallois points	29	27.1	1	0.4
Levallois flakes	30	28.0	11	4.7
Levallois blades	24	22.4	19	8.1
Levallois fragments	1	0.9	33	14.1
non-Levallois flakes	3	2.8		
non Levallois blades	2	1.8	6	2.6
Kombewa flakes			1	0.4
cores:				
Levallois cores			19	8.1
non-Levallois cores			2	0.8
cores on flakes	2	1.9	2	0.9
core fragments			1	0.4
total	**107**		**235**	
debris < 2cm:			185	

Tab.55: Composition of the *remanié* and trench P50 Mousterian sample of Nadaouiyeh Aïn Askar. Note that the *remanié* sample comprises surface collections which did not comprise small debris.

Tab.55

	analyzed	length			width			thickness			LWR		
		mean	min	max	mean	min	max	mean	min	max	mean	min	max
cortical flakes	31	5.5	2.2	11.0	3.4	1.0	6.0	1.0	0.3	2.0	1.7	0.6	3.2
flaking surface flakes	21	5.0	2.8	10.6	3.4	1.8	6.4	0.8	0.3	1.8	1.6	0.4	2.7
core edge flakes	13	6.5	4.8	10.0	3.0	1.0	5.7	0.8	0.4	1.3	2.6	1.4	4.9
Levallois blades	19	7.1	3.4	10.2	2.7	1.1	4.8	0.6	0.3	1.1	2.9	1.9	6.8
Levallois flakes	11	5.7	3.3	7.5	3.5	2.6	4.3	0.6	0.3	0.8	1.6	1.3	1.9
Levallois cores	19	4.8	3.5	6.7	4.1	2.6	5.7	2.0	0.8	3.3	1.2	1.0	1.6

Tab.56: Mean, minimum and maximum length, width, thickness and length width ratio (LWR) of diagnostic artifact categories of the Nadaouiyeh trench P50 sample.

	IF	IFs	Ilam	LWR mean	% retouched
Yabroud:					
KS2	71.4	64.9	48.1	2.1	20.2
KS10	55.4	44.3	43.7	2.0	12.0
Hummal:					
5AIV	82.6	80.4	33.6	1.9	11.6
5a2	94.7	93.2	34.6	1.8	25.3
5a3	94.6	93.2	53.9	2.0	24.3
5b3	91.9	91.2	47.7	2.0	16.9
5E	90.0	90	63	2.3	20.0
5e-5f2	88.5	88.5		2.0	44.8

Tab.57: Comparison of Yabroud KS 2, KS 10 and selected Hummal assemblages in respect to basic technological features. LWR = length width ratio

	analyzed	mean length	mean width	mean thickness	mean RT
KS2	262	6.6	3.3	0.7	0.33
KS10	284	5.5	2.8	0.6	0.42

*T-Test for surface size (L*W):*

Levallois flakes: t = 5.191; p = 0.000

Levallois blades: t = 4.804; p = 0.000

Levallois points: t = 4.940; p = 0.000

Tab.58: Comparison of flake size between Yabroud KS 2 and KS 10; note that the size difference between each level is statistically significant for each blank category. RT = relative thickness (T / (L+W)*0.5)

	KS 2		KS 10	
	N	%	N	%
retouched Levallois blades	4	7.0	3	8.3
retouched Levallois flakes	6	10.5	3	8.3
retouched Levallois points	10	17.5	6	16.7
simple side scrapers	16	28.1	10	27.8
double side scrapers	5	8.8	3	8.3
side scrapers on ventral face	2	3.5	1	2.8
Mousterian points	4	7.0	4	11.1
end scrapers	3	5.3	2	5.6
burins	2	3.5	0	0.0
notched pieces	3	5.3	2	5.6
denticulates	2	3.5	2	5.6
total	*57*	*100.0*	*36*	*100.1*

Tab.59: Composition of the retouched tool sample in Yabroud KS 2 and KS 10.

	Unit IX								
beds	**63**	**64**	**66**	**66B**	**66Q**	**67**	**68**	**total**	
first flakes		1	5		1		7	14	1.7%
cortical blades	9	3	5	1			3	21	2.5%
cortical flakes	6	10	4			1	10	31	3.7%
crested blades		1						1	0.1%
core tablets	3		2				2	7	0.8%
core edge blades	7	6	6	1			5	25	3.0%
core edge flakes	5	2	11	1			4	23	2.8%
striking platform flakes	1	3	2				3	9	1.1%
flaking surface flakes	9	19	13	1	1		12	55	6.6%
core trimming elements s.l.	2	7	3				9	21	2.5%
non-Levallois blades	10	6	28	1			2	47	5.7%
non-Levallois flakes	4		2		1		4	11	1.3%
non-Levallois points							1	1	0.1%
Levallois blades	30	27	62	1			18	138	16.6%
Levallois flakes	24	7	19	1			19	70	8.4%
Levallois points	40	15	21			1	12	89	10.7%
indeterminable		1	1					2	0.2%
total debitage	**150**	**108**	**184**	**7**	**3**	**2**	**111**	**565**	**68.2%**
Levallois flake cores	1	1	3				1	6	0.7%
Levallois blade cores	1							1	0.1%
Levallois point cores	2	1		1			1	5	0.6%
preferential Levallois cores			1				2	3	0.4%
discoidal cores	1						1	2	0.2%
flake cores	2	1	5[a]				4	12	1.4%
blade cores	1	1						2	0.2%
prismatic blade cores		2			1			3	0.4%
dorsal cores on flake	4	1	2				4	11	1.3%
ventral cores on flake			4				1	5	0.6%
multiple cores on flake			1				1	2	0.2%
total cores	**12**	**7**	**11**	**1**	**1**		**15**	**47**	**5.7%**
Levallois fragments	26	12	38		1		6	83	10.0%
core trimming fragments	27	9	20					56	6.8%
fragments indeterminable	6	1	34	1				42	5.1%
core fragments		6	11				9	26	3.1%
total fragments	**59**	**28**	**103**	**1**	**1**		**15**	**207**	**25.0%**
handaxes	**2**					**1**	**2**	**5**	**0.6%**
total beds	**223**	**143**	**303**	**9**	**5**	**3**	**143**	**829**	**100.0%**

[a] including one flake core from bed 66A

Tab.60: Composition of the Tabun unit IX sample (Jelinek collection, University of Arizona, Tucson).

Tab.60

Tab.61

	analyzed	length	width	thickness	LWR		RT		WTR	edge angle
		mean	mean	mean	mean	sd	mean	sd	mean	mean
prismatic blades	44	7.1	2.2	0.7	3.3	1.0	0.16	0.04	3.1	46.5
prismatic flakes	9	5.0	4.1	1.2	1.4	0.6	0.24	0.11	4.2	51.4
Levallois blades	135	7.3	2.7	0.6	2.8	0.6	0.13	0.06	4.7	39.6
Levallois flakes	69	5.5	3.4	0.5	1.7	0.3	0.12	0.03	7.3	35.9
Levallois points	89	6.3	2.9	0.6	2.3	0.6	0.12	0.06	6.0	41.0
total	346									
N° of blanks with LWR >= 2		**239**								
Ilam		**69.1**								

T-test for prismatic blades vs. Levallois blades

	t	p
LWR	3.757	0.000
RT	5.173	0.000
WTR	-4.161	0.000
edge angle	4.785	0.000

Tab.61: Mean size, length width ratio (LWR), relative thickness (RT), width thickness ratio (WTR) and mean edge angle of Levallois and non-Levallois blank categories of the Tabun unit IX sample. The significant frequency of laminar pieces in unit IX is expressed by the number of blanks showing a LWR of over 2.0 and the laminar index (Ilam). The morphological difference between Levallois and prismatic blades in terms of volume distribution is best explained by a significant differences in length width ratio, relative thickness, width thickness ratio and edge angle.

Tab.62

	analyzed	% faceted	% dihedral	% plain	% cortical	% indet.	WDR[a]
prismatic blades	46	*17.4*	*4.3*	*60.9*	*10.9*	*6.5*	2.9
prismatic flakes	11	*9.1*		*90.9*			3.1
Levallois blades	138	*67.4*	*8.7*	*16.7*	*0.7*	*6.5*	4.0
Levallois flakes	69	*72.5*	*2.9*	*17.4*	*1.4*	*5.8*	5.0
Levallois points	88	*80.7*	*6.8*	*10.2*		*2.2*	5.8
total	352						
IF	**69.6**						
IFs	**63.4**						

[a] width depth ratio measured on the striking platform

Tab.62: Frequency of butt-types among different blank categories of Tabun unit IX and related faceting indices (IF, IFs). The width depth ratio (WDR) determines the thinness and elongation of the butt surface.

length	N	cdg[a]	3 negatives	PBI: 25th percentile[b]
< 6cm	44	*65.9*	*77.3*	*1.1*
> 6cm	46	*47.8*	*30.4*	*0.8*

[a] percent of points with a *chapeau de gendarme*

[b] 25th percentile of the proximal breadth index (PBI = butt-length / width)

Tab.63: Division of Levallois points from Tabun unit IX into the large (> 6cm) and small group (< 6cm) and examination of point-specific features.

tool type	N	%
retouched core trimming elements	3	2.2
retouched non-Levallois blanks	3	2.2
retouched Levallois flakes	2	1.5
retouched Levallois blades	7	5.2
retouched Levallois points	13	9.6
Pseudo-Levallois points	1	0.7
Mousterian points	9	6.7
retouched Hummalian points	2	1.5
single side scrapers	35	25.9
double side scrapers	20	14.8
side scrapers on ventral face	9	6.7
alternate retouched side scrapers	5	3.7
perforators	3	2.2
end scrapers	2	1.5
burins	1	0.7
naturally backed knives	13	9.6
notched pieces	3	2.2
denticulates	3	2.2
miscellaneous	1	0.7
total	*135*	*100.0*
ILty_real	**82.3**	
ILty_restricted	**63.6**	

Tab.64: Tool counts and the typological Levallois index (ILty) of Tabun unit IX.

Tab.64

				Unit I			
beds	**18**	**19**	**21-22**	**21**	**22**	**total**	
first flakes				4	2	6	1.2%
cortical blades	2	1		3	3	9	1.8%
cortical flakes	4	6	1	13	7	31	6.4%
core tablets				2		2	0.4%
core edge blades		4		4	1	9	1.8%
core edge flakes	1	1		4	11	17	3.5%
striking platform flakes	1	2			4	7	1.4%
flaking surface flakes	6	4		17	12	39	8.0%
core trimming s.l.				3	9	12	2.5%
non-Levallois blades		1		1		2	0.4%
non-Levallios flakes		1			1	2	0.4%
Kombewa flakes		1			1	2	0.4%
Levallois blades	3	7		7	6	23	4.7%
Levallois flakes	12	10	1	26	7	56	11.5%
Levallois points				2		2	0.4%
indeterminable				1		1	0.2%
total debitage	**29**	**38**	**2**	**87**	**64**	**220**	**45.1%**
Levallois flake cores	1	2		2		5	1.0%
Levallois blade cores		1		1		2	0.4%
preferential Levallois cores	1			2	1	4	0.8%
flake cores	1	2		7	1	11	2.3%
blade cores					1	1	0.2%
prismatic blade cores		1				1	0.2%
dorsal cores on flake	1				2	3	0.6%
ventral cores core on flake	1	1			1	3	0.6%
multiple cores on flake					1	1	0.2%
total cores	**2**	**2**			**4**	**8**	**1.6%**
Levallois fragments	17			10	18	45	9.2%
core trimming fragments	33			33	30	96	19.7%
indeterminable fragments	32			21	26	79	16.2%
core fragments	6			7	4	17	3.5%
total fragments	**88**			**71**	**78**	**237**	**48.6%**
percentage burned	*89.8%*			*56.3%*	*47.4%*	*65.8%*	
total beds	**167**		**2**	**170**	**149**	**488**	**100.0%**

Tab.65: Composition of the Tabun unit I sample (Jelinek collection, University of Arizona, Tucson).

Tab.66

	N	length			width			thickness	length width ratio
		mean	Min	Max	mean	Min	Max	mean	mean
Levallois blades	22	7.5	4.7	13.1	3.2	2.0	4.6	0.8	2.4
Levallois flakes	53	5.9	2.7	10.7	4.4	2.6	8.9	0.6	1.4

Tab.66: Mean size and length width ratio of Levallois blades and flakes from Tabun unit I.

	Levallois blades		Levallois flakes	
	N	%	N	%
unidirectional parallel	5	*25*	8	*16*
convergent	1	*5*		
perpendicular			5	*10*
bidirectional	6	*30*	3	*6*
semi-centripetal	2	*10*	14	*28*
centripetal	3	*15*	13	*26*
indeterminable	3	*15*	7	*14*
total	20	*100*	50	*100*

Tab.67: Frequency of scar patterns among Levallois blades and flakes of Tabun unit I.

Tab.67

tool type	**N**	**%**
Retouched core trimming elements	2	6.7
Retouched Levallois flakes	1	3.3
Pseudo-Levallois points	3	10.0
Single side scrapers	8	26.7
side scrapers on ventral face	2	6.7
Double side scrapers	3	10.0
Naturally backed knives	5	16.7
Notched pieces	2	6.7
Denticulates	3	10.0
Miscellaneous	1	3.3
total	*30*	*100.0*
ILty_real	**83.5**	
ILty_restricted	**63.6**	

Tab.68: Tool counts and related typological Levallois index (ILty) in Tabun unit I.

	IF	IFs	Ilam	LWR mean points	flakes	blades	points
Kebara [a] *:*							
IX	79.3	78.1	9.6		63.2	22.4	14.4
X	75.4	71.9	13.3		59.3	22.6	18.1
XI	70.2	64.1	20.2		61.1	30.5	8.4
XII	87.5	83.3	22.9		59.0	29.9	11.1
Amud [b]*:*							
B1	49.3		27.1	2.0[c]	56.3	35.81	8.16
B2	37.1		25.4		43.4	22.65	33.97
B4	52.0		16.2	2.5[c]	31.3	30.23	38.37
Tor Faraj [d] *:*							
floor I & II combined				1.4	57.0	18.8	24.2
floor I	42.0		25.9				
floor II	46.5		36.4				
Hummal:							
5AII	84.6	84.6	54.7	2.3	31.1	42.2	26.7
5AIV	82.6	80.4	33.6	1.9	41.3	23.2	35.5
5a2	94.7	93.2	34.6	1.7	41.3	30.7	28.0
5a3	94.6	93.2	53.9	1.9	31.1	36.5	32.4
5b3	91.9	91.2	47.7	1.9	39.0	37.5	23.5
5E	90.0	90.0	63.0	2.6	32.0	44.0	24.0

[a] Meignen 1991; Meignen & Bar-Yosef 1992; note that for Kebara subtriangular flakes and atypical points were subsumed in the flake group

[b] Hovers 1998; Ohnuma & Akazawa 1988

[c] mean length width ratio of elongated points only

[d] Henry 1995, 2003

Tab.69: Comparison of basic technological parameters and assemblage composition expressed as percentage of flakes, blades and points between the Late Mousterian sites of Kebara, Amud, Tor Faraj and Hummal.

Tab.69

Curriculum Vitae

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03/2004 - 2010	PhD: *„The Mousterian sequence of Hummal (Syria)"* Institute for Prehistory and Archaeological Science (supervisor: Prof. J.-M. Le Tensorer)
12/2003	Master's Degree in Prehistory (Basel University); Dissertation: *"Die mittelpaläolithische Fundstelle Mutzig-Felsbourg (Bas-Rhin, Alsace). Techno-typologische Analyse der Artefakte aus Sondage M12."*
10/1997 – 12/2003	Studies in Prehistory: Albert-Ludwigs-University in Freiburg i.Br. 10/1997 – 07/1999 Subjects: Prehistory, Ethnology, English language and literature Basel University 10/1999 – 12/2003 Subjects: Prehistory, Ethnology, Physical Anthropology

Research Activities and Archaeological Experience

Since 2010	Co-Director of excavation in the Mousterian site of Mutzig (Alsace, Bas-Rhin, France) Technical Assistant at the Pôle d'Archéologie Interdepartemental Rhénan (Séléstat, France)
Since 2008	Participant in research project "L'occupation du sol dans la vallée de la Bruche du Paléolithique au Moyen Age." Direction: G. Triantafillidis / G. Oswald (SRA, Alsace)
Since 09/2005	Assisstant Director of the Syro-Swiss research project *„Le Paléolithique d'El Kowm (Syrie)"*; direction: Jean-Marie Le Tensorer (Basel University); Funded by Swiss National Foundation, Tell Arida Foundation

Since 09/2003:	Excavations in the Middle Palaeolithic deposits of Hummal (El Kowm, Syria); direction: Jean-Marie Le Tensorer (Basel University). Funded by Swiss National Foundation, Freiwillige Akademische Gesellschaft Basel

2004	Excavation in Roucadour Cave (Thémines, Lot); direction: M. Lorblanchet (Toulouse university), J.-M. Le Tensorer (Basel University)
1999 – 2002	Excavation in Acheulian site of Nadaouiyeh Aïn Askar (El Kowm, Syria); Direction: J.-M. Le Tensorer / R. Jagher (Basel University
1999	Excavation of hematite-quarry at Sulzburg (Mesolithic, Neolithic) (Baden-Württemberg, Germany; direction: G. Goldenberg (Freiburg University)
1998	Excavation of Villa Rustica (Roman period) near Rottweil (Baden-Württemberg, Germany); Direction: Ch. Maise (Freiburg)
1997	Excavation of Early Neolithic settlement structures at Herbolzheim (Baden Württemberg, Germany); Direction: Ch. Maise (Freiburg)

Studies of Lithic Collections

Since 2003	Analysis of the Mousterian collection of Hummal (El Kowm, Syria); Museum of Palmyra, Syria
2010	Analysis of the Mousterian assemblages of Tabun (Mount Carmel, Israel); Smithsonian Collection, Washington DC
2008	Analysis of the Mousterian assemblages of Tabun (Mount Carmel, Israel); University of Arizona, Tucson.
2007	Analysis of the Mousterian layers 10 and 2 of Yabrud (Syria); Institut für Ur- und Frühgeschichte der Universität zu Köln, Germany.
	Analysis of selected assemblages of Le Moustier, La Ferrassie, Combe Grenal and Pech de l'Azé IV (France); Musée National de Préhistoire, Les Eyzies, France.

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Conference Presentations

04/2010 Hauck, Th., Wojtczak, D.: Trends and Diversity in the Middle Paleolithic Sequence of Hummal. Paper presented at the 75th SAA Meeting, St. Louis, MI, USA.

02/2010 Hauck, Th.: Neue Daten zum Mousterian von Hummal (El Kowm, Syrien). Paper presented at the Research Colloquium, Universität zu Köln, Cologne, Germany.

09/2009 Hauck, Th.: *Palimpsest vs. „Pompei" premise. How to interpret Mousterian levels in the site of Hummal (Syria)?* Paper presented at the 5th Graduate Colloquium, Institute for Prehistory and Archaeological Science, University of Basel, Switzerland.

11/2008 Le Tensorer, J.-M., Schmid, P., Hauck, Th., Schuhmann, D., Wegmüller, F., Wojtczak, D.: *The Oldowan in the Palaeolithic Sequence of Hummal, Syria*. Poster presented at the International Congress "The oldest human expansions in Eurasia. Favouring and limiting factors", CNRS / Muséum National d'Histoire Naturelle, Paris, France.

10/2008 Hauck, Th.: *Hunting the Big Camel. Mousterian Occupations of Hummal*. Paper presented at the Basel Conference "The Lower and Middle Palaeolithic in the Middle East", Basel, Switzerland.

04/2008 Hauck, Th.: *The Paleolithic Sequence of Hummal (Syria)*. Paper presented at the Research Colloquium, Department of Anthropology, University of Arizona, Tucson.

02/2008 Hauck, Th.: *The work of Linda Owen - Distorting the Past. Gender and the Division of Labor in the European Upper Paleolithic.* Paper presented at the 2nd Graduate Colloquium, Institute for Prehistory and Archaeological Science, University of Basel, Switzerland.

03/2007 Hauck, Th.: *The Paleolithic sequence of Hummal (El Kowm, Syria)*. Paper presented at the Research Colloquium, Max-Planck-Institute for Evolutionary Anthropology, Leipzig, Germany.

05/2006 Hauck, Th.: *The Mousterian Complex of Aïn Hummal*. Paper presented at the Workshop for Palaeolithic Archaeology in Syria, Damascus, Syria.

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